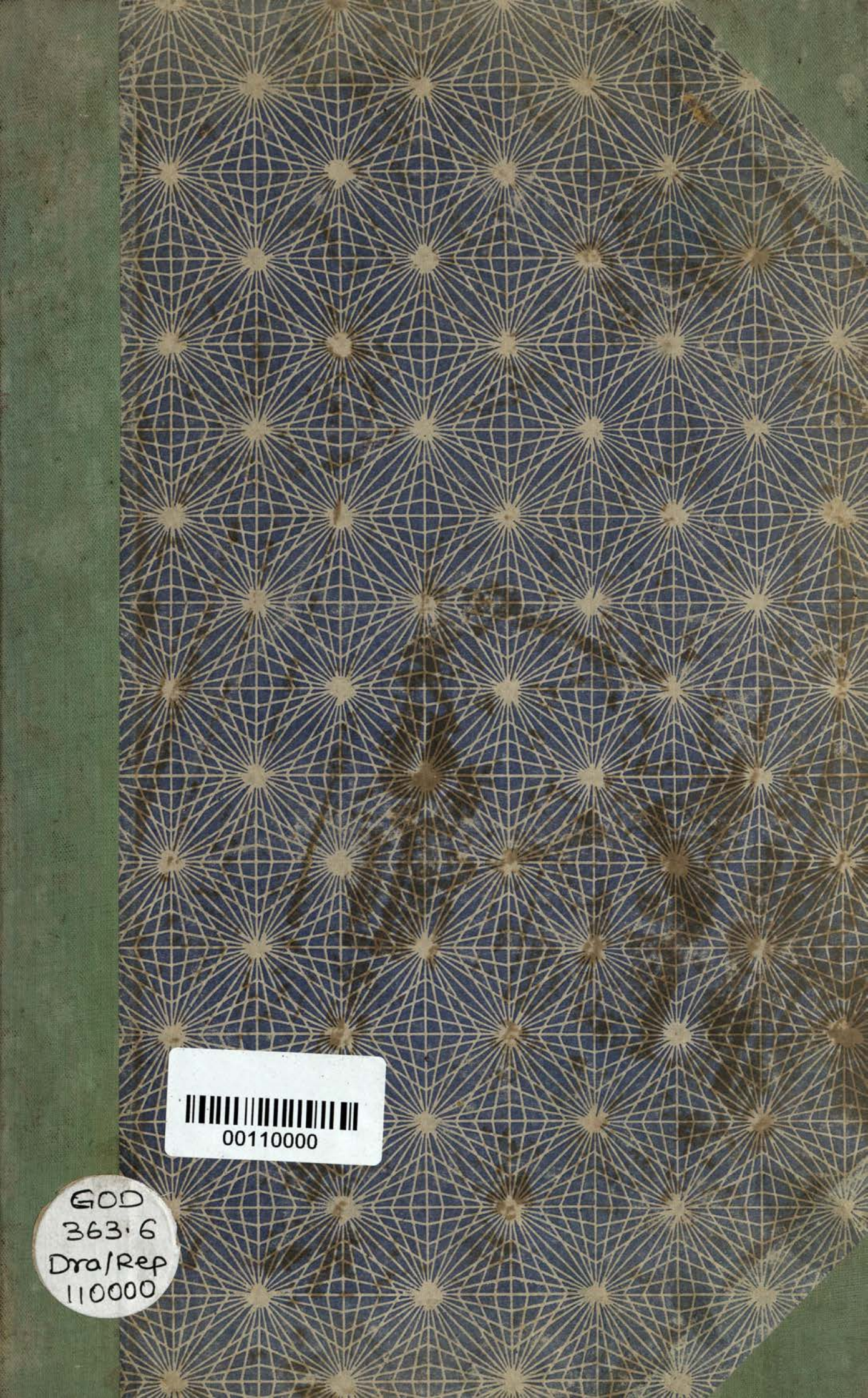

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DRAINAGE AND WATER SUPPLY OF BOMBAY.

REPORT

OF THE

Commission on the Drainage & Water Supply

BOMBAY.

110000

WITH APPENDICES.

Bombay:
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REPORT

ON THE

Drainage and Water Supply

OF

BOMBAY.

1. The Commission appointed by Government in reference to the Drainage and Water Supply of Bombay have the honour to submit the following Report.

2. The duty of the Commission was twofold :

(1.) To "ascertain if the details of Captain Tulloch's drainage scheme had been correctly worked out, and whether it possessed any engineering or sanitary defects, either as regards the principle adopted, or in the mode of applying that principle ; also, whether, from the data before the Commission, they considered that the project could be executed at the cost at which it had been estimated—*i.e.*, whether Captain Tulloch's calculation fairly represented the outlay that would be involved in giving effect to his project."

Government Resolution 11 of 1869, P. W. D., dated 12th January 1869.

(2.) To "consider Mr. Russel Aitken's schemes for increasing the water supply, and to report on their relative general advantages, and to examine and discuss the details of that which they might consider most suitable, should they be of opinion that either of them was calculated to effect satisfactorily the object in view."

3. In reference to the first point of enquiry, the object of Government in issuing the Commission was expressed to be, "not only to secure that the best scheme for the drainage of the city should be adopted, but to satisfy themselves that the financial conditions of the proposal were such as would justify them in

Government Resolution No. 24 of 1869 (P. W. D.), dated 21st January 1869.

recommending that the assistance of Government should be given in order to facilitate the raising of capital required for its execution;" and in connection with this enquiry, the Commission were authorized to "receive any evidence referring to the general principles of other schemes, if the Commission considered that such evidence bore on the question submitted to them."

Government Resolution No. 31 of 1869 (P. W. D.), dated 1st February 1869.

4. Of the six gentlemen originally appointed on the Commission, two —Messrs. Ormiston and Le Messurier—were unable to serve; and the enquiry has, with the sanction of Government, been conducted by the remaining four members of the Commission.

Government Resolution No. 55 of 1869 (P. W. D.), dated 23rd February 1869.

WATER SUPPLY.

5. The first point to which the Commission directed their attention was the question of an increased water supply to Bombay. Under this head they had to consider four schemes submitted by Mr. Russel Aitken, lately the Executive Engineer to the Municipality. These schemes may be thus shortly summarized;—

(1.) The Shewla Scheme, with a reservoir of 4,000 acres, a dam 90 feet high, and a main of 4 ft. 6 in. diameter, and 56 miles long; to cost 1[illegible] lacs; and to yield from 25 to 30 gallons per day per head of the present population.

(2.) The Canery Scheme, with a reservoir of 500 acres, a dam [illegible]6 feet high, and a main 32 in. diameter, and 22 miles long; to cost 41½ lacs; and to yield from 10 to 12 gallons per day per head of the present population.

(3.) The Toolsee Scheme, for increasing the supply in the Vehar Lake; to cost 16½ lacs, and to yield 5 to 6 gallons per head per day.

(4.) The Poway Scheme, with a reservoir of 980 acres, and a main 36 in. diameter, and 13 miles long; to cost 35½ lacs; and to yield 10 to 12 gallons per head per day.

The sites of these schemes are shown on the annexed map.

6. With regard to the Shewla scheme, the Commission consider that it is too gigantic a work to be undertaken by the Municipality. Its cost would appear, if anything, to have been under-estimated by Mr. Aitken; for Mr. Ormiston puts it at two millions sterling, and Captain Tulloch at 180 lacs. The proposal to carry the water for a distance of fifty-six miles in an exposed steel main is also, in the opinion of the Commission, too novel an experiment to be tried on so large a scale in the first instance; and, without adopting Mr. Blaney's opinion that the water would "come into Bombay in the afternoon in a state for boiling

...gg, warming a child's conjee, or giving a rheumatic patient a hot bath," the Commission have no doubt that, should it be found necessary to bring water to Bombay from so great a distance, a masonry conduit would be in every respect preferable to a steel main.

7. The Canery and Poway schemes are both open to the objection that they are mere patches upon Vehar, and incapable of extension from time to time to meet the growing requirements of the city. The enormous height of the impounding dam at Canery, and the quantity of valuable land that would be submerged at Poway, are additional reasons against the adoption of either of these projects; and the Commission are of opinion that neither of them is calculated to effect satisfactorily the object in view.

8. Reserving for the present the consideration of the Toolsee scheme, the Commission venture to express their conviction that no scheme involving any considerable outlay should be adopted by the Municipality or sanctioned by Government, unless it combines the least possible engineering risk in the method of its construction, with a capability of inexpensive extension from time to time to meet the growing wants of the population. By the last census the inhabitants of the town and island of Bombay numbered 816,562; and it is reasonable to suppose that, in the course of the next twenty or thirty years, this number will be considerably augmented. In the construction of new and costly water works, the future as well as the present wants of the city should be borne in mind.

9. The Commission were therefore at some pains to enquire what quantity of water is needed for the daily consumption of the people. At present, says Mr. Blaney, "the largest proportion of this population limit themselves to a daily supply of two gallons per head," for all purposes. This, as he justly observes, is "vastly insufficient;" and he would allow fifteen gallons per head per day for the ordinary uses of the people. Mr. V. N. Mundlik considers ten or twelve gallons daily quite sufficient. Mr. Cursetjee Framjee says that Parsees cannot manage with less than 14 gallons per head per day; and Mr. Eduljee Nusserwanjee is of the same opinion. The Commission, therefore, consider that a *minimum* of fifteen gallons * per day per head of the population should be provided for domestic consumption, irrespective of what may be required for watering roads, extinguishing fires, flushing drains, and other public purposes.

10. This being conceded, it becomes important to enquire what are the sources and amount of the present water supply of Bombay.

11. The present water supply of Bombay is derived from three sources: 1. The Vehar Lake; 2. Public Wells and Tanks; 3. Private Wells and Tanks. As will be presently shown, however, only the first of these sources can be relied on to yield water fit for human consumption.

* The Army Sanitary Commission allow 12 gallons per head for every healthy man, woman, and child in an Indian military station.

12. From the Vehar Lake about 8,500,000 gallons are daily delivered for the consumption of the city. Taking the population to be about 800,000, this quantity is equal to something more than 10 gallons per head per day. It is thus distributed :—

Mr. Aitken's Report, p. 3.

To the Public *(gratis)* :

42 Dipping Wells	312,000	gallons.
31 Drinking Fountains 19 Stand Pipes	300,000	,,
Watering the Roads	250,000	,,
Hospitals, Schools, &c.	18,275	,,
	880,275	,,

Sold by Meter :

To Government	355,000	gallons.
,, Factories and Railways	328,890	,,
,, Irrigation	42,250	,,
,, Shipping	17,330	,,
,, Private Meters	530,000	,,
	1,273,470	,,
Balance otherwise available and expended in private service	6,346,255	,,

The quality of the water thus supplied is very good, as is shown by the following analyses, made by Dr. Lyon, the Secretary to the Commission :—

	Total solid matter.	Loss on ignition.	Chlorine.	Lime.	Magnesia.	Total Earthy Salts as Carbonate of Lime.	Sulphuric Acid.	Total Oxygen required by the Water at 140° F. in presence of acid.	Ammonia. Of Nitrates and Nitrites.	Ammonia. In distillate from Carbonate Soda.	Ammonia. In distillate from Permanganate of Potash.
Vehar Water from supply pipe. October 1st 1868	5·98	·49	·99	1·80	·82	4·37	...	·0205	...	...	...
Vehar Water from supply pipe. April 1st 1869	6·72	·91	·87	1·72	·73	4·90	...	·0262	Trace.	·0042	·0092
Vehar Water from supply pipe. June 1st 1869	7·00	·84	·77	1·64	·86	5·07	Trace	·0227	·1260	·0170	·0134
Vehar Water from supply pipe. July 1st 1869	5·60	·84	1·04	1·50	·62	4·35	do.	·0367	·0042	·0077	·0127
									Nitric Acid (Approximate.)		
Dipping well, No. 7 Camateepoora Bazaar Street, Sept. 1868.	9·17	·98	1·04	1·02	·51	3·09	do.	·0284	·21		
Do. 2nd Coombharwada Street, do.	5·95	·77	1·22	·79	·46	2·56	do.	·0428	·19		
Do. No. 10 Dongree Bazaar Street, do.	7·51	1·89	1·17	1·18	·36	3·55	do.	·0284	·15		

13. The number of wells and tanks not supplied with Vehar water is 4,802. Some of these are public, but the great majority are connected with private houses. The public tanks are described by Dr. Lumsdaine as "nothing more than huge cesspools, in which persons and clothes, wash and are washed, in a water that is never changed." The private wells are little better. Speaking of those in the Fort, Mr. Eduljee Nusserwanjee says ; "Generally the distance between the sewer of the house and the well is very little ;" and "in some cases the distance between the privy and the well is as little as six or seven feet." Those in the native town are equally badly placed ; and there can be no doubt that into all these wells there is a large percolation of impure matter. Moreover, since the introduction of Vehar water, these wells

Evidence, p. 35.

Evidence, p. 40.

low average rainfall were to occur, there would be a considerable risk of the lake becoming exhausted, if the consumption were not proportionally restricted.

20. The Commission next desire to call attention to the system of distribution of Vehar water in force in Bombay. Of the 25,664 houses in Bombay, only 7,419 are connected with the Vehar pipes; and it seems clear from Mr. Crawford's evidence that it is impossible to increase the number of house connections.* These 7,419 houses, containing on an average 30,000 families, consisting of about 220,000 persons, absorb upwards of six millions of gallons daily; or, in other words, considerably less than one-third of the population monopolises three-fourths of the water supply. The Commission cannot consider this a satisfactory arrangement. There can be no doubt that so long as the water supplied for private service is not gauged by meter, there is much unnecessary waste; and, under present circumstances, all preventible waste is a positive fraud on the public. They, therefore, recommend that all water supplied to private houses should henceforward be paid for according to meter measurement; and that, with a view to render the water that will thus be economized available for the general service of the public, small iron dipping wells, of the description suggested by Mr. Blaney, should be provided throughout the native town. The Commission are also of opinion that great advantage would follow from the setting apart of public bathing-places, under Sec. 174 of the Municipal Act.

Appendix, p. 56.

21. The income derived from the Vehar Water Works during the last five years is shown in the following table:—

Income for	By Meter.	By Rate.	Total.
1864.....	Rs. 7,349 13 0	Rs. 3,05,690 6 3	Rs. 3,13,040 3 3
1865.....	„ 37,956 4 0	„ 2,67,924 0 11	„ 3,05,880 4 11
1866.....	„ 1,91,546 10 11	„ 2,15,774 3 6	„ 4,07,320 14 5A
1867.....	„ 1,90,445 11 5	„ 1,94,591 14 11	„ 3,85,037 10 4B
1868.....	„ 2,17,395 6 9	„ 1,79,075 6 5	„ 3,96,470 13 2C

A—Includes.....Rs. 21,000 0 0 on account of Government Water Rate.
B—Includes... ..... „ 21,000 0 0 „ „ „
C—Includes ..... „ 1,14,680 6 4 „ „ „

Rs...1,56,680 6 4

The expenses of maintenance have been as under:—

—		Remarks.
1864 } 1865 }	Rs. 2,06,138..	This includes adjustments for former years.
1866	„ 1,04,604..	
1867	„ 1,71,471..	Includes about Rs. 46,000 for repairs of dam.
1868	„ 78,600..	Approximate only; accounts not closed.

Note.—The above figures include engineer's establishment and contingencies for maintenance and for distribution, also labourers' wages, purchase and repair of stores and pipes, but not cost of assessment and collection and of general superintendence.

* The following table shows the number of house connections:—

1860 208	1863 3,422	1866 6,750
1861 1,061	1864 5,198	1867 7,526
1862 2,085	1865 6,470	1868 7,419

The meters number as under:

1865 ..... 317 | 1866 ..... 501 | 1867 ..... 527 | 1868 .....

The charges have been as follows:—

Before 1st January 1866.	After 1st January 1866.
By Meter—Per 1,000 gallons, 8 as.	*By Meter*—Per 1,000 gallons, Re. 1.
By Assessment—	*By Assessment*—
7 per cent. on the assessed valuation of the house.	5 per cent. on the 1st, 2½ per cent. on the 2nd, and 1¼ per cent. on the 3rd, and each succeeding Rs. 100 of the assessed valuation.

The charge to Government has been two-thirds of the above rates.

As it is very probable that the alteration in the system of distribution recommended by the Commission may cause some diminution of the revenue, the Commission consider that a light general water rate should be levied by the Municipal Commissioner, (under Sec. 85 of the Act), and made payable in like manner as the House Rate. From this rate houses supplied with water by meter should be partially if not entirely exempt.

22. The Commission are not of opinion that any commensurate advantage would be obtained by watering the roads with sea water. The cost of constructing pumping engines and laying down pipes would, they think, be better spent in increasing the supply of fresh water to the town.

23. But while it is the opinion of the Commission that by greater economy of distribution, and the addition of the Toolsee water, much will be done to alleviate the evils of the present scanty water-supply of Bombay, it is no less their conviction that no time should be lost in securing a full and permanently reliable supply of water to the town. Even with the addition of Toolsee, the supply from Vehar will be sufficient only for an intermittent service, a *minimum* supply for domestic uses, and an unreliable supply in case of fires. The recommendations of the Commission, therefore, so far as they have gone, point only to temporary measures of relief. A continuous service, at full pressure, is what is required for Bombay, and Bombay should be satisfied with nothing less. This, the Commission consider, will be most securely obtained by a low level reservoir, from which the water should be brought by a covered masonry conduit to Bombay;* and they recommend that surveys should be made without delay, with a view to carrying out this proposal. With such a reservoir, not only could the supply of water to Bombay be made to keep ahead of any possible increase of the population,† but all the water not required for Bombay might be made available for the service of towns on the road,‡ for the supply of the railways, and for irrigation.§ In this point of view, the work might fairly be regarded as an imperial work, and not one of a merely local municipal character.

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* See the evidence of Captain Tulloch (App. pp. 19-26); of Captain Ducat (App. pp. 37-38); and Mr. Aitken (App. pp. 47-49).

† A channel 8 feet square, with a semi-circular arch over it, will carry 65 millions of gallons per day, which is equivalent to 75 gallons per head daily of the present population of Bombay. The cost of such a channel would be about Rs. 1,30,000 per mile.

‡ *E.g.*, Bhewndy, Callian, Tanna.

§ The Commission much regret that they were unable to obtain the evidence on this point of Lt. Col. Fife, R.E.

DRAINAGE.

24. In considering Captain Tulloch's scheme for the drainage of Bombay, the attention of the Commission was directed to two points: 1. Whether it possessed any engineering or sanitary defect, either as regards the principle adopted, or in the mode of applying that principle; and 2. Whether Captain Tulloch's calculation fairly represented the outlay that would be involved in giving effect to his project.

25. As a preliminary enquiry, under the first head, it became necessary for the Commission to consider what system of drainage is, on sanitary and engineering grounds, best adapted to the requirements of Bombay. The Commission, therefore, proceed briefly to state their views upon the general question, at the same time that they discuss Captain Tulloch's project.

26. Every complete system of town conservancy should provide for the removal of the following sources of impurity:—

(*a.*) Solid refuse, such as *débris* of food, vegetables, &c.
(*b.*) Rain-water.
(*c.*) Refuse water from kitchens, baths, &c.
(*d.*) Latrine matter, both solid and fluid.

27. The best system is that which provides for the continuous and complete removal and disposal of these sources of impurity, by means involving the least possible injury to the public health.

28. The problem to be solved, therefore, involves two branches: 1. How best to carry away these impurities to a safe distance from human dwellings; and 2. How to get rid of them in an innocuous and, if possible, a profitable manner.

29. With regard to the first class of impurities—solid refuse—little need be said. It is collected by hand labour, deposited in large bins which have been erected in convenient positions throughout the town, and thence removed in carts to a siding at Boree Bunder, from whence it is carried by rail to Coorla, a distance of nine miles from Bombay, where it is spread over a tract of swampy ground belonging to the Municipality. This is probably as satisfactory a method as could be devised for its disposal.

30. The next point is the disposal of rain-water, which in Bombay is a serious question during four months of the year. The Commission are of opinion that it should be removed, to as great an extent as the levels will permit, by gravitation, direct into either Back Bay or the Harbour; and that no rain and storm waters which it is possible to divert by either the construction of new underground channels, or by surface drains, should be allowed to pass down through the present drains on to the Flats near the Breach Vellard.

31. While, therefore, the Commission entirely agree with Captain Tulloch in desiring "to effect a complete separation of rain from sewage," they cannot concur with his proposal to carry off the rain water by the present underground drains to the present main drain, "by which it will be carried to Love Grove, where it will be pumped into the sea." This, in the opinion of the Commission, would be a costly and unsatisfactory process. Mr. Rawlinson says :—"Any attempt to provide large sewers to receive tropical storm waters, and steam power to pump the same, must either be most extravagantly costly, or must fail;" and the calculations made by Mr. Ormiston as to the expense of pumping confirm this view.

Report, p. 23.

Report, p. 32.
Evidence, p. 112.

Report to Secretary of State, "Bombay Municipal Record," p. 112.

32. As the leading feature of Captain Tulloch's project is to pump not only the storm water, but the sewage, of Bombay into the sea, the Commission consider that it is, in that respect, objectionable on engineering grounds.

33. With regard to the disposal of the two remaining classes of impurities—the refuse water and latrine matter—the first question which the Commission had to consider was, whether the night soil should be allowed to pass into the drains. This, in a climate and community like those of Bombay, is a question of the most serious importance to the public health, and, if decided in the affirmative, would involve a radical change in the habits of the bulk of the population. To carry out with any degree of safety *in Bombay*, a system of drainage similar to that of any English city, *would* necessitate the introduction of water-closets, and the Commission are of opinion that this could not be successfully accomplished. Dr. Lumsdaine says :—"If there is to be water-carriage, there must be water-closets; and it will take some time, I think, to adapt the native houses for these. Admit that they would use them, and there is still the difficulty about repairing them. They would also require a continuous water-service, and no matter how much the payment was in arrears, you could never cut off the supply." But there is a graver objection, which is well stated by Mr. Blaney: "In the large sewers the disengagement of noxious gases would be very considerable. Direct connections of the sewers with native houses would necessitate traps and sinks; but I don't know that we could get a trap which would be beyond the reach of the tenants, and the gases would be coming into the houses with the thermometer in the month of May at from 90° to 95°, which would be a very serious matter, and I should expect a heavy death-rate. I cannot find words strong enough to express what I consider would be the danger of such a proceeding." Dr. Lumsdaine also says :—"I am in favour of the present halalcore service being continued, because as yet I have not heard of any tested method by which you can get rid of the gases that would be engendered if the night soil were passed into the drains. Until this problem be solved, we had better keep to our old system, disgusting and rude though it be."

Evidence, p. 108.

Evidence, p. 133.

34. The Commission consequently consider Captain Tulloch's project objectionable on sanitary grounds, inasmuch as it proposes to carry off all the night soil by means of sewers.

35. The Commission are aware, from the evidence which has been laid before them, that, under present circumstances, a large proportion of night soil—Mr. Aitken says fifty per cent.—finds its way into the sewers; and there is no doubt that, from the habits of the people, this will always, to a certain extent, be the case. But as the halalcore system is perfected, the quantity will diminish year by year; and it is not unreasonable to hope that before long it will be reduced to a minimum.

Evidence, p. 94. Analyses, App., p. 143.

36. How, then, is the night soil to be disposed of?

37. The present system is thus described by Dr. Lumsdaine: "The night soil is removed by hand. At certain points throughout the town there are stations and iron cylinder carts. Upon these points the halalcores work, and as the carts are filled at the stations, they go to the main depôt at Boree Bunder, where there are two receiving tanks. These tanks have a discharge-pipe that delivers at (the end of) Carnac Bunder" into the Harbour. Dr. Lumsdaine considers this system satisfactory, "if it were more complete;" and states that the halalcores serve 14,738 houses, or about two-thirds of the whole number of houses in Bombay, and that they clear off "pretty nearly the whole of the night soil that is to be found *in the houses*." Mr. Blaney believes that "the halalcore system, *although it is an expensive and an imperfect system*, is capable of much improvement. . . . . It is a system that we must not depart from until we are sure that we have found a better one;" and he adds that he thinks the halalcores do their work pretty thoroughly.

Evidence, p. 87.

Evidence, p. 134.

38. With regard to the discharge of the night soil at Carnac Bunder, Dr. Lumsdaine says he is not aware of any objection to it, "if discharged when the tide is going out." Mr. Ormiston says, "I am less afraid now than I was at a former time of polluting the Harbour, more thoroughly understanding the advantages which we have here by the diurnal variation of the tide;" but he adds, "still it is a great nuisance—I have no doubt about that; and if there could be any other means of disposing of it, it should be adopted."*

Evidence, pp. 120, 125.

39. Two other methods of dealing with the night soil were brought to the notice of the Commission: 1. The dry-earth system; and 2. Captain Tulloch's project of sewage utilization for agricultural purposes.

40. The dry-earth system could not, in the opinion of the Commission,

* Might not the pollution of the harbour be prevented by delivering the sewage at Carnac Bunder into hopper barges, in which it should be taken out to sea, and discharged? This could be done during the fair season, if not throughout the year.

be introduced into a large city like Bombay. According to the Army Sanitary Commission, "the matter from latrines, including solid and fluid excreta, amounts to about 1 lb. per man per day, or, in round numbers, half a ton per day per 1,000 men. The quantity of dry earth required for latrines alone is about 2½ lbs. per man per day, proportionately increased if the latrine is used oftener than once. To absorb and deodorize the urine of one man about 7 lbs. of dry earth is required per day. Thus, for 1,000 men, the total daily amount carted into the station and distributed would be 9,500 lbs., and the amount to be collected and carted away would be 12,000 lbs. The daily movement of earth and soil would thus be nearly 10 tons for 1,000 men." These figures are conclusive that, from its cost and from the practical difficulties which would attend the mere cartage, distribution, collection, and removal of so much earth, the dry-earth system is inapplicable to any large community. In jails, barracks, and hospitals, where strict discipline is maintained, the system may possibly be made to work; but in a free community it is impracticable.

Memorandum upon the dry-earth system of sewage.

41. With regard to sewage utilization, the Commission, while fully recognizing the advantages which would result from its successful introduction into India, cannot but hesitate to recommend the trial of so gigantic an experiment as would be involved in the adoption of Captain Tulloch's scheme. They think there is the less reason for trying the experiment in Bombay, as it is now on the eve of being tried in Calcutta. Sewage utilization has it advocates there, at least as enthusiastic as its advocates in Bombay. But one of the foremost among them, Dr. Chevers, though asserting that thereby "the now deadly swamps eastward of Calcutta may be made, in ten years, the *gardens* of the country," judiciously qualifies his opinion thus:—"*While* strongly recommending the reclamation of the Salt Lake and the extensive utilization of the sewage of Calcutta in manuring the land thus obtained, I cannot say that I believe the measure to be unattended with risk. . . . The utilization of the entire sewage of so large a city as Calcutta has never yet been attempted even in a temperate climate. Here it will be attended with dangers, the obviation of which will demand considerable science and unremitting care." And Dr. Smith, the Sanitary Commissioner for Bengal, writing on the same subject, says:—"That the lake should be scientifically recovered from its now barren and boggy condition, there can be no doubt; but whether human excreta in enormous quantity (either in its natural condition, or largely diluted with water) *should ever be allowed* to reach its soil, is quite another question, regarding which there is a mass of conflicting evidence."

Report on the Drainage and Conservancy of Calcutta, p. 57.

42. In this doubtful state of things, the Commission consider that it would be extremely unwise to incur the large outlay which Captain Tulloch proposes for sewage irrigation. They learned with pleasure that the Municipal Commissioners had been trying experiments on a small scale near the Love Grove Sluices, and that those experiments had been comparatively successful. It may therefore be expected that before long these problems will be solved; 1.

Whether the native cultivators will use and pay for sewage as manure; and 2nd. To what crops and land sewage manure is best adapted. But for the solution of the great problem—whether sewage irrigation to a vast extent can be carried on in the tropics, without injury to health, in the neighbourhood of so large a town as Bombay—the Commission consider that it would be wise to await the result of the great experiment about to be attempted in Calcutta.

43. For the reasons above stated, the Commission feel themselves unable, either on engineering or sanitary grounds, to recommend the adoption of Captain Tulloch's project for the drainage of Bombay.

44. As, however, there is an impression abroad that the drainage of Bombay is miserably defective, and requires immediate alteration, the Commission think it will be useful to summarise the information they have obtained on the subject.

45. At Colaba there are few drains of any kind; but waste and rain water finds its way into the Harbour and Back Bay. There is halalcore service, and the night soil is carried out to sea as far as possible. The drainage of Colaba was not included in Captain Tulloch's scheme.

46. For the Fort, a system of drainage on the combined principle, by which the rain is carried through the same sewers as the sewage matter, is being constructed, according to a design of the late Mr. Tracey, at an estimated cost of Rs. 4,20,000. These works have been stopped for the present, but the drains, so far as they have been constructed, are said by Mr. Aitken to work very well, both in fair weather and monsoon.

Evidence, p. 92.

47. The Esplanade is drained chiefly by the absorbent power of the subsoil, but partly by connection with the drains of the Fort and Native Town.

48. The Native Town, wherein three-fourths of the inhabitants reside, drains partly into the Harbour and partly into Back Bay, but by far the greater portion of it drains towards the Flats. The bulk of the sewage is carried off by the main drain to Love Grove Sluices, where it is pumped into the sea at all states of the tide. Every street has its drain, though the oarts are badly supplied. The old drains are imperfectly constructed; but in some districts, as at Camateepoora, new drains have been made with the happiest results. The houses are connected with the drains by means of gullies. The cost of cleaning the drains is about a lac and a half per year.

49. The rest of the island is left very much to its natural drainage.

50. It is conceded by Captain Tulloch that "a careful examination of the map of Bombay can hardly fail to convince an engineer that the natural drainage lines run along"

Report, p. 6.

the streets in which the principal drains are now constructed. This is a great advantage, of which the most should be made in any efforts to improve the drainage of Bombay. But the Commission do not think it advisable to improve or maintain all those drains. The levels of low-lying districts are being raised every year, and Mr. Ormiston is inclined to believe that the island could be effectually, or nearly effectually, drained by gravitation.* With improved surface drainage, and an improved halalcore system, Dr. Lumsdaine thinks there is no necessity for a system of sewers to carry away the night soil. The attention of the Municipality should therefore, in the opinion of the Commission, be specially directed to constructing sewers having their outlets in the Harbour for draining by gravitation as much of the island as the levels will admit of, and to improving the present halalcore service.

51. With regard to the Fort drainage, as the scheme is complete in itself, and the money required for the execution has been raised by loan, the Commission consider that it should be proceeded with and completed without delay.† The Commission would, however, recommend that the house connections should be so constructed as to prevent, as much as possible, the admission of noxious gases into the buildings. A simple contrivance for achieving this object is described by Captain Tulloch.

52. The Commission desire also to draw attention to the night-soil reservoir at Carnac Bunder. It is insufficient in size, and the discharge-pipe is carried not only under the railway, but under the piers of the adjoining over-bridge. The Commission recommend that the reservoir should be enlarged, and the pipe relaid, so as to be easily accessible throughout its whole length in the event of any stoppage taking place in the pipe.

53. The Commission further recommend that the number of public necessaries should be largely increased. There are at present only fourteen in Bombay—a very small number as compared with the wants of the population.

54. The Commission are aware that in recommending delay in undertaking any great scheme for the extension of water supply or the reconstruction of the drainage of Bombay, they expose themselves to much adverse criticism, not only from the numerous class of persons interested in the execution of large projects, but from those who have the sanitary improvement of the city really at heart. But after careful consideration, the Commission have come to the conclusion that not one of the projects submitted to them fulfils those conditions of certainty and economy which would justify them in recommending it for adoption. They are unable to affirm that any of the works proposed is of

* "I would endeavour," he says, "to induce the people, by assistance or otherwise, to raise the ground which is at present too low to be drained by gravitation. It is not a large area, only 170 acres altogether."—Evidence, p. 122.

† Captain Tulloch says:—"If the Government thought that the Fort was so small a place that the sewage might be discharged into the sea, I should not offer any objection. If this system were really hereafter to be a nuisance, nothing would be easier than to rectify it, for all you would have to do would be to extend the main drain and pick up the Fort sewage."—Evidence, p. 99.

indisputable necessity for the preservation of the health of the city of Bombay ; and they do not think that a few years' further delay is likely to be productive of injurious consequences. If, in the interval, the recommendations of the Commission with regard to the extension and improvement of existing works are carried out, they consider that time will have been gained to ascertain the result of experiments now in progress, while provision has been made, without incurring any heavy liabilities, for the increasing requirements of the town.

A. R. SCOBLE.
W. KENDALL, COL. R.E.
J. S. TREVOR, LIEUT.-COL. R.E.
W. G. HUNTER, M.D., M.R.C.P.,
Surgeon, Bombay Army.

I. B. LYON, *Secretary.*

Bombay, July, 1869.

APPENDICES.

APPENDIX A.—MINUTES OF EVIDENCE.

MINUTES OF THE EVIDENCE

TAKEN BEFORE THE

Bombay Drainage & Water Supply Commission.

FIRST DAY, MARCH 17, 1869.

The following Commissioners were present—

ANDREW R. SCOBLE, Esquire, *Chairman.*
Colonel KENDALL, R. E. | Lieut. Colonel TREVOR, R. E. | Dr. HUNTER.
Dr. LYON, *Secretary.*

The Commission met at 2 o'clock P.M., in the Town Hall, Bombay.

The SECRETARY read the Resolution of Government and other documents relative to the appointment of the Commission and defining its objects.

Mr. RUSSEL AITKEN put in plans of his schemes for water supply from Shewla, Canery, Toolsee, and Poway.

The examination of Mr. Aitken was reserved until after evidence had been given by other witnesses upon the different schemes.

MR. THOMAS ORMISTON, C.E.:—

MR. ORMISTON—I have given considerable attention to Mr. Aitken's Shewla scheme since the meeting of the Justices, owing to the remarks of the Municipal Commissioner. I shall give the Commissioners the results of my calculations; but I may state at the outset, that they confirm my opinion in the impossibility, pecuniarily, of carrying out the Shewla scheme. Of course these are very much matters of expense, and Mr. Aitken has given his estimates sufficiently in detail, to unable one to discuss them with some confidence. The first large item is for embankments, which are put down at one rupee per cubic yard overhead. Now, without knowing the precise conditions, it is impossible to say whether this is sufficient or not. But the manner in which the work would require to be done is tolerably expensive. The material for the embankment would require to be carried on people's heads for some distance. Working it out in detail it would turn out thus: the cost price of getting and filling into baskets would be three annas per yard; I take it also that it would require one anna per cubic yard for watering, thus leaving twelve annas for carrying it, which would be enough for 800 yards of lead. But it would be under only the most favourable circumstances that you could get so large a quantity of suitable material so close to the work. The quantity of material in Shewla dam, for instance, is 612,600 cubic yards, and that would require an area of 100 acres, four feet deep, or for the Canery dam the same area but more than six feet deep, so that it would be a very favourable circumstance which

would enable the work to be done for the money. I should be inclined to say that Mr. Aitken's estimates for the dams, supposing the sites are favourable, are tolerably fair; if anything they are under-estimated. The large item, however, in the Shewla scheme is the steel main, the cost of which is put down at £840,000, at Mr. Aitken's price and strength. Now steel, although it has lately taken a very important place in the manufactures of the country, is not yet so well understood that you can depend thoroughly upon the uniformity of its strength. The latest information on that point is to be found in Mr. Read's work upon ship-building. Mr. Read is Constructor of the Navy, and has had every opportunity of obtaining official information on the strength of steel. He has recently published a book upon ship building, in which he devotes a chapter on steel plates, and in which he says, with regard to a series of experiments made in Chatham Dockyard in 1864—"The material was of Bessemer manufacture, the conditions being that it should stand 33 tons per square inch lengthwise, and 30 tons crosswise; the results were very remarkable: the material was shown to have one-third more strength than was expected when it fractured fairly, but it was also shown to have an erratic mode of fracturing, which caused a variation in the breaking strain per square inch of original area between 43¾ tons and 25½ tons, or regarding the fractured area there is a variation between, say, 15 and 60 tons; there appears to be nothing in the circumstances to account for these eccentricities." Again he says—"These experiments might by many persons have been held sufficient to prove that Bessemer steel plates were altogether unsuited to the use of the shipbuilder." Again, with regard to half-inch Bessemer plate, which had formed one of the upper deck plates of the "Hercules," and suddenly snapped one morning succeeding a cold night, he says—"Whatever was the cause, it was evident that some of the best English Bessemer steel makers were not then to be trusted in the performance of this most important duty—the careful annealing of plates after manufacture." He also says—"The foregoing results with steel in H. M. Dockyards show what just ground there is for extreme caution in its use in the form of plates." On the other hand he says—"Hereafter when the peculiarities of the Bessemer steel are better understood by makers and shipbuilders, and when the price is reduced by the termination of the present royalty, it will in all probability be used almost exclusively by shipbuilders and engineers;" and "the uniformity of strength in some cases, where the manufacturers make Bessemer steel plates an important part of their business, is admirable;" and "Bessemer steel plates may be said to vary in tensile strength from about 30 to 50 tons per square inch, but they are most useful for shipbuilders when they are between 32 and 38 tons, say 35 tons, or about 50 per cent. stronger than first-class iron." But this is the result of his experience—"It may be said indeed with truth that if steel supplied by first-class makers is treated in the same manner as iron in working it into a ship, it will require to be of the same thickness as the best iron in order to obtain the same strength." I therefore think it would be unsafe to trust to steel being at present stronger than the best Lowmoor iron. Taking it at that strength it would be necessary that the tube should be half an inch thick. Besides that, I think Mr. Aitken has made an omission in the quantity, even at three-eighths of an inch in thickness, because, so far as I can see, he has made no allowance for butt strips for overlapping the joints. The quantity he has given is very little more than the weight of a steel-tube in one plate, as it were, throughout the whole length. Now that is of course impossible, and I have supposed that it would be made in plates fifteen feet long and about three feet six inches broad, of which it would take four in the circumference. Now the addition of these butt strips alone would add to Mr. Aitken's quantities, 102 tons, besides the rivets, 20 tons, so that if it was only three-eighths of an inch thick there would be 634 tons to the mile instead of 530. To make it half an inch thick would add 211 tons, which makes a total of altogether 845 tons instead of 530. At Mr. Aitken's price that works out three-quarters of a lac of rupees per mile extra, in all to Rs. 42,00,000, besides one and a half lac for carriage, which is a very large addition to his estimate. I would add something more, because I think Mr. Aitken has taken the price of steel too cheap. My own impression is, although I have not made enquiries, that the price is about £40 a ton instead of £20. But I am not able to speak about that with certainty, and Mr. Aitken will probably give you definite information; it occurred to me that it might be said if steel is not to be trusted more than Lowmoor iron, why not make the main of iron? This main would require to withstand a pressure equal to the boiler of a locomotive, say 140 lbs. to the square inch. Therefore, it would be necessary to make it of the best Yorkshire boiler plate. The price of Monk Bridge plates in 1861, up to 6 cwt., was £30 per ton, whereas Mr. Aitken's estimate is only £20 a ton for steel. Plates of the size I have supposed would be 7 cwt. if 3/8th sheets and 9 cwt. if half inch. And the price increases rapidly as the weights of the plate increase. I speak under correction, but I think the price too low. On the whole, therefore, I believe that the

cost of the steel main is very much under-estimated. The fixing is only put down at Rs. 30 per ton, and according to the work that boiler-makers can do in this country, it would cost fifteen rupees for riveting alone, and the caulking would cost as much, which make Rs. 30 without putting the pipes in place. This item I also consider under-estimated. Mr. Aitken does not show the line of the main on the map, but it must cross the Tanna Creek and the river at Callian, besides several smaller streams and many roads, but nothing is put down for special works at these places. On the whole, I am satisfied that the Shewla scheme, as proposed by Mr. Aitken, could not be carried out under two millions sterling, and it would probably be considerably more. It occurred to me that it might be possible to bring the water down in the way water is generally brought in large quantities, that is by an open duct. In estimating this, however, I laboured under this disadvantage, that Mr. Aitken has given no sections of the country between Bombay and Shewla. But even if a suitable line were got for the water course, it would still be a very considerable work, although I think it might have been proper to have looked into it more narrowly than seems to have been done. Supposing, however, that we adopted this plan, I take it that the works to bring the whole quantity into the neighbourhood of Bombay would cost £600,000; but that, I must warn you, is exceedingly vague, because I have not been over the country, nor has any information been given on this point. But in addition to that sum, you would require to pump the water to such a height as to enable it to work with the Vehar pressure, and that would certainly raise the cost to at least one million sterling. Therefore, taking the Shewla scheme in whatever way you like, it will cost, in the cheapest way it can be carried out, at least one million sterling.

The CHAIRMAN—In calculating it at a million, do you include the cost of making the reservoir near Bombay?

Mr. ORMISTON—I do; and I capitalise the cost of pumping as much water as we now have from Vehar. I have started upon the assumption that an addition to the supply equal to what we get from Vehar is quite sufficient for Bombay.

Colonel TREVOR—Do you calculate that the water should be brought in an open duct all the way to Bombay?

Mr. ORMISTON—No; I would have some miles of piping. I would bring the duct as near as it could be brought, so as to be beyond the reach of inhabitants, probably to some part in Salsette.

Colonel TREVOR—But if you capitalise the cost of pumping, you do not include a longer pipe than we have now from Vehar?

Mr. ORMISTON—When I spoke of a million sterling, for bringing the water from Shewla, that was for bringing a quantity equal to the present Vehar supply from a few miles out of Bombay, and with a pipe from the reservoir sufficient to do that. But you must understand that if you want to get 50,000,000 gallons of water, you would require to put down additional pipes, and that the cost would be very much increased beyond the first one million. Although there is not sufficient information to enable one to go into it carefully, there is, to my mind, sufficient to show that th Shewla scheme should be discarded.

The CHAIRMAN—Before you leave the Shewla scheme, Mr. Ormiston, there is one question I should like to ask you. You allow one anna per yard for watering the embankment. Do you think that is sufficient?

Mr. ORMISTON—Yes, I think so; the water would be brought near the site of the dam, and then bheesties would distribute it.

The CHAIRMAN—Do you think there is sufficient water in the neighbourhood, that one anna would cover the cost of carrying it over.

Mr. ORMISTON—I have not calculated the cost of bringing the supply to the place.

The CHAIRMAN—Then you have merely calculated for the distribution of the water?

Mr. ORMISTON—That is all.

Colonel TREVOR—Would not it be possible to make tanks, as was done before?

Mr. ORMISTON—You might do that. Then I start with this, that as far as the present population of Bombay is concerned, there is no urgent necessity for increasing the supply of water very largely. I have also a feeling that the population of Bombay has been exaggerated, that it never has reached the 800,000 generally named. I have been told on very good authority that when the Census gentlemen brought in the returns they were told that the numbers were not sufficient, and that they went out again, and brought in more. (Laughter.) However that may be, my own expectation with regard to the population of Bombay is, that it will not increase so largely or so soon as some suppose.

There are indeed changes going on now which will tend to decrease the population. There is at present a large number of people employed in pressing cotton here, but as cotton becomes more and more pressed up-country, there will be fewer labourers required here, and when the railways get to the harbour and discharge their loads alongside the wharfs, there will be less necessity for carters. So that I should not consider it necessary now to make an allowance for a very large increase in our population. The Vehar Water supply, if we were perfectly certain of it, would enable us to keep going for some time. As it is, we might draw more from Vehar by erecting an engine to supply the higher districts of Bombay, and give an artificial head. But as we cannot depend on the Vehar supply, it would I think be quite sufficient to provide for another supply of an equal quantity, which might be got at Canery.

The CHAIRMAN—Would you give us your reasons why you would not wish to depend upon Vehar?

Mr. ORMISTON—Not from any fault that one can see in the dams, because they are in a better state than they have been in for many years, but simply from the general insecurity which attaches to all works of this kind. There have been similar works erected in the most careful way and on the best principles, which have stood for many years, but those works have failed.

Colonel KENDALL—You can always ascribe that to faulty construction?

Mr. ORMISTON—It may be so; but there is the fact. Hidden defects in the soil on which a bank rests, or even such a little thing as a water rat, may effect it. According to theory, they should stand for ever, and if everything was tight and good, they would do so; but what has happened elsewhere may happen at Vehar.

Colonel KENDALL—You say that instances have occurred. Do you remember any particular instances where the dams have failed? There was the Holmfirth accident, but that might be ascribed to the totally wrong engineering construction of the work. It is patent that the work was defective. Can you recall any other instances of any dam, carefully looked after, constantly inspected, and constructed with all due regard to engineering principles, having failed?

Mr. ORMISTON—There have been others, but I was only engaged upon the failure of one dam myself, or rather of a series of dams consequent on the upper one having given way. I was sent down to report upon certain failures on the Crinan Canal. There there was a series of dams which had been constructed under the direction of Mr. John Rennie, and I presume with the usual amount of superintendence. These dams had been in existence for fifty years. They were made in 1806, and failed in 1857. The first dam failed, and the water of it came down upon the water of the next one and overtopped it, and the water of that came down upon the next, and so on; and so they all failed. Engineers are not infallible. You may say, after a work has failed, that you see what was wrong with it. If it were not a case of life and death, you might be justified in running the risk; but with us in Bombay, I consider it is a case of life or death, and that those who are responsible are not justified in running the risk.

The CHAIRMAN—Then you object to relying upon one source of supply?

Mr. ORMISTON—I do. And the more dams the greater the risk. You have three dams at Vehar and only one at Canery, so that the risk is not so much at Canery as at Vehar, other things being equal, because there is only one dam to go.

Colonel TREVOR—Is not the danger in proportion to the height ordinarily?

Mr. ORMISTON—I don't know in what proportion it is, but it is greater with a high than with a low dam.

Colonel TREVOR—You look to the possibility of the dam failing?

Mr. ORMISTON—I do.

The CHAIRMAN—I believe that at Vehar the pipe goes through the embankment. Is not that an additional source of danger?

Mr. ORMISTON—It is.

Colonel TREVOR—That principle is now condemned?

Mr. ORMISTON—Yes; all engineers now agree in turning the flanks of the dams by carrying the outlet pipe through the solid.

Colonel KENDALL—In the principal towns in England, Manchester for instance, are they dependent upon one source of supply? I went down there, and I think I only saw one reservoir.

Mr. ORMISTON—In the case of Loch Katrine works, the dam is only ten feet or so altogether; the bund works there are light, but the lake is of great area.

Colonel TREVOR—That is not the case at Manchester or Liverpool?

Mr. ORMISTON—Liverpool and all large towns I know of have many sources of supply. But in India we are much worse off than people are at home, because supposing your supply failed in Manchester or Liverpool, rain is so much more constant than here, that you could soon get some temporary works, and get a temporary supply at any rate. There, again, the whole ground is charged with water, and you could have pumping from springs brought into requisition, and no doubt you would find wells wherever you dug.

Colonel TREVOR—Are we worse off now than we were before the Vehar water works were made?

Mr. ORMISTON—Yes; for many tanks have been filled up.

Colonel TREVOR—But is there not more water in the strata now than before the Vehar pipes were laid?

Mr. ORMISTON—I think not.

The CHAIRMAN—But supposing the pipes in the dams became corroded, and there was great leakage in the pipes themselves, would it not endanger the dam?

Mr. ORMISTON—It would.

The CHAIRMAN—And what means are there of getting inside to repair the leakage of the pipes?

Mr. ORMISTON—I believe there is a sluice in the water tower, so that you can go into the outlet pipe from the outside; if the pipe is showing symptoms of weakness or decay it should be lined.

Colonel TREVOR—It would be possible to close up this pipe altogether, and put in a fresh one, raising it to a much higher level, and you would still have the supply you have?

Mr. ORMISTON—Yes; it would be the same head.

Colonel TREVOR—And you would reduce the danger very much?

Mr. ORMISTON—So far as that particular class of danger is concerned.

Colonel TREVOR—And you would add to the strength of the dam by throwing more earthwork on it?

Mr. ORMISTON—Not materially. I think that the pipe could be made tolerably safe by lining it, or, as you say, you could have another pipe laid at a much higher level through the solid. When I was last at Vehar the leak through the dam had been very much checked, in fact almost stopped, by the works which Mr. Russel Aitken had carried out, through the recommendations made by the Committee some three years ago.

Colonel TREVOR—Do you think that year by year that leakage will decrease. The sand has a natural tendency to silt up the bottom and gradually strengthen the dam?

Mr. ORMISTON—It would be a very small amount of strengthening, a few inches in the course of a very considerable number of years.

Colonel TREVOR—I do not think that accords with our experience of all the tanks in this country. They generally silt up pretty soon.

Colonel KENDALL—In nearly every case of a dam failing in this country it is owing to the waste weirs not being sufficient for the water going over the top.

Mr. ORMISTON—I don't think there is any fear at Vehar on that account. Be that as it may, notwithstanding every care you can possibly take, what you say shows that dams do give way sometimes.

Colonel KENDALL—But that is, as far as I remember, the only source of danger—the waste water not going into the proper channel.

Mr. ORMISTON—That was not the cause of the failure of the Sheffield dam. But, as I said before, dams do give way sometimes, and it would be a great misfortune if we lost Vehar. I therefore think it is desirable to have another source of supply.

Colonel TREVOR—Then would you call that an emergent expenditure?

Mr. ORMISTON—Certainly I would; I should make it take precedence of all other municipal expenditure. I do not say that you should attempt it if your exchequer is empty. If you have not means to start the work fairly and ensure its going on in a continuous manner, it would probably be better to wait until you are in that position.

Colonel TREVOR—For instance, should it take precedence of the drainage?

Mr. ORMISTON—Yes; most decidedly.

Colonel TREVOR—And do you think the evils would be very much greater hereafter than in former years when we had no Vehar supply?

Mr. ORMISTON—I do. At that time the tanks were more numerous than they are now, and the population was less; the mortality was also greater, and I think that that was caused to a very great extent by the people drinking bad water.

Colonel KENDALL—If some of the tanks in town were cleaned out in the hot weather, and filled during the monsoon from the Vehar Lake, that water would keep in very good condition during the whole year ?

Mr. ORMISTON—As an abstract proposal I have no doubt it would, and if you knew exactly when any of the Vehar dams were to fail, it would be desirable to get all the tanks cleaned out, and fill them with fresh clean water.

Colonel KENDALL—I mean to say, could it not be a standing regulation that all the tanks should be cleaned out in the hot weather, and filled again during the monsoon ?

Mr. ORMISTON—That would be a very expensive process. If you had seen the pumping out of the Baboola tank, you would be aware that such a thing as that could not be made a practice of—it could not be entertained financially. I happened to take a walk to Malabar Point the other night and met a gentleman who had been asked to pump out Walkeshwur tank, and I agreed with him that it would be almost impossible to get down a pumping engine to the place. In point of fact, it would be a very expensive operation, and could not practically be carried out. These tanks are largely used by people washing themselves and their clothes in them, and I am satisfied Colonel Kendall would not care about drinking the water out of them after seeing that.

Colonel KENDALL—The only question is whether there is any necessity for a second independent water supply, or whether these tanks should not be cleaned out, in case of emergency, during the dry season, and filled with pure water during the monsoon.

Mr. ORMISTON—I am satisfied that would not answer. I may state that I don't know of any large town, or indeed any town, which is running such a risk as Bombay is now doing in respect to its water supply; it would take two or three seasons before you could fill the lake should there be any accident. You could not do it in one season. You could not work during the rains there, for there is such a large amount of rainfall. It would take a dry season to make the breach good, and it would take two seasons more to fill the lake. The first monsoon would only bring it up half way or a very little more ; as you will see by the chart, which Mr. Aitken has drawn up, it shows how much the water rose the first year, and that it took two monsoons to fill the take; so that you could not restore the supply in one season in case of an accident. Holding, as I do, that view, I believe it is necessary to have another reservoir. I have gone into a calculation of the Canery scheme, and I don't think Mr. Aitken is very much out there. I think it is rather low in some things. I think, however, that the Commission might safely take £500,000 as the total cost. The cost of Vehar has been 45 lakhs, that of the Canery scheme would be 50 lakhs, and if it were necessary, the Poway might be added, which would give a total cost of 131 lakhs of rupees and a daily supply of 27 millions of gallons. I have not here included 15 lakhs for distributing pipes already spent in connection with the Vehar supply. We are already committed to the expenditure on Vehar, and suppose you now go to Shewla your expenditure must be at least a million sterling in addition. I believe it would be more than two millions, but with the smallest expenditure, you are up to the same amount with Shewla and Vehar as you are with all the others and little more water. So that upon every head, prudence and economy in gradually making the supply suitable to the requirements of the town, I take it the schemes should be constructed in the manner I have stated—Vehar, which now exists, Canery, and if required, Poway. In the construction of Poway you would take more care probably to make better dams than we have at Vehar. I ought to have remarked, when Colonel Trevor spoke about the waste weir and the dams at Vehar, that I think the repairs, which Mr. Aitken made two seasons ago at the Vehar dams, have been so efficient, that, so far as my judgment goes, the Bench need not expend the two lakhs which are put down for extra repairs. There was a remark of Mr. Aitken's which misled me a little at first, and that was about the use of the Shewla water for working factories. He says (Appendix A.) that if all the water were used for that purpose it would give 1,850 H. P. at an annual *saving*, when compared with steam power, of five and a half lakhs of rupees; but he does not take into account, in speaking of this annual *saving*, the interest on the cost of the works which would be required to produce that water power; if you take that into account, coals are cheaper than water at Bombay. There is only one other point which I should like to name, and that is with regard to the Canery dam. It is a great height—136 feet—and if you look to the section of it, you will see that the gorge of the valley widens suddenly at a point about 80 feet below the top. I should be inclined to treat the part below that as a special risk, and make the dam there seventy feet wider than the regular slopes would give by making a 50 feet berm on the inside and another 20 feet on the outside, something like what I have shown here very roughly. (Showing a plan and explaining it to the Commissioners.)

Colonel KENDALL—There is no doubt that is an improvement.

Mr. ORMISTON—The extra cost of that would be half a lakh. I think we should also avoid putting a pipe through the dam. I do not see that Mr. Aitken has any details of that.

Mr. AITKEN—Yes; the details are given there. You will see it is not intended to go through the dam.

Mr. ORMISTON—If there was any difficulty about it, it could be worked by a syphon. Mr. Aitken produces a drawing showing the sections, and the pipe carried in a tunnel through the rock below the dam. I think, to the best of my recollection, I have said all I had to say on the subject. I would add that I think there ought to be a public water rate. There is a public water rate in most towns, I believe. In Glasgow it is 1d. per £, and in Greenock 3d. per £: some of the Greenock people think it very dear: but I think 1 per cent. would be given freely in Bombay. I do not pay for water myself at my bungalow. The bheestie brings it from a well, which has a supply of Vehar water. I believe many gentlemen are in the same position, and don't pay for it.

The CHAIRMAN—Do you consider the height of the impounding dam at Canery itself an element of danger?

Mr. ORMISTON—The higher the dam the greater the danger.

The CHAIRMAN—Do you know of any dam of that height?

Mr. ORMISTON—I don't know of any impounding dam higher than 80 feet.

Colonel TREVOR—There are some French weirs higher than that, I believe,—are there not?

Mr. ORMISTON—Perhaps; but I think they are of masonry.

Colonel TREVOR—Yes; I think they are.

Mr. ORMISTON—You would get this information better from Mr. Aitken, who has, no doubt, been looking into that subject. I believe 80 feet is quite manageable and common enough. I have not seen a dam as high as 136 feet. The quantity of material in the Canery dam is very large in proportion to the quantity of water impounded, and it does not compare favourably with any others that I know of in that respect.

The CHAIRMAN—The present supply from Vehar is 12 gallons per diem per head of the present population,—do you consider that a sufficient supply?

Mr. ORMISTON—I do for domestic purposes, not if irrigation is to be encouraged. On this point Mr. Hawkesley says, in a report he made to the Town Council of Plymouth about their water works—"It has been conclusively ascertained that with good management on the part of those having charge of the water works, twelve gallons per head will suffice for the domestic supply, even in large towns, in which water closets and soil pans are the chief sources of waste, are more than usually numerous." He says in another part of the same report that "the lowest return of the water revenue in towns in which, as at Plymouth, the manufacturing requirements are not considerable, afforded from all sources an average of two shillings and sixpence per head per annum; without a return of this average amount no public water works can be efficiently constructed and efficiently maintained."

Colonel TREVOR—In Calcutta the Government laid down water in Fort William to every room and every place in the barracks, and the consumption there, including water for roads and many things else, was only ten gallons per head per diem.

Mr. ORMISTON—As far as drinking and cooking are concerned, I may state that I had the management of a Rock Lighthouse at one time, where all the water had to be carried to the men, and for cooking and washing the amount was one gallon per head per diem. As a rule you will find this—that in all cities the more water you give the people the more they will waste, and I believe that the present supply of Vehar water would be sufficient for us if we could be sure of it.

Colonel KENDALL—What is the effect of giving too great a supply in a town, especially in a low-lying town?

Mr. ORMISTON—The effect is very bad, for the water goes into the ground, and you have a malaria, with all the effects of an ill-drained district. Messrs. Robert Stephenson and I. K. Brunel pointed this out very distinctly when reporting on the supply of Glasgow in 1855. They say—"It would seem that the quantity of water consumed by the population of large towns follows no rule, but has hitherto been simply dependent on the supply—that is to say, whatever the extent of the supply, the wants or the habits of waste of the inhabitants have grown with that supply, and the result is that the quantity consumed varies in different towns from 10 to 70 or 80 gallons per head per diem, and the question really seems to be reduced to this—what quantity of water is it desirable that any given population should consume? However beneficial may be the effects of an ample supply of water, particularly in a

crowded city, there can be no doubt that the abuse of such a blessing may be productive of very serious sanitary evils, and anything which leads to an excessive consumption of water is therefore undesirable."

Colonel KENDALL—According to the present mode in which Vehar water is distributed in the native town—I do not refer to where water is let into European houses, but where water has all to be drawn from stand pipes in the street—nothing like 12 gallons per head is used per diem.

Mr. ORMISTON—No; because it requires to be carried. The consumption in my own bungalow is about seventeen gallons per head, but I have three horses and two bullocks and a garden. Mr. Aitken shows that the quantity taken is eight million gallons, and if there are 800,000 people, that is only ten gallons per head for all purposes. That was the amount of water which went through the pipe at Freelands.

Colonel KENDALL—That includes all the water wasted beyond that?

Mr. ORMISTON—Yes, beyond that.

Colonel KENDALL—And the water used for roads and everything else—garden, irrigation, and everything else?

Mr. ORMISTON—Yes. There is a plan in Mr. Aitken's report (Diagram No. I.) showing the quantity taken out every year from Vehar; and that it runs down from 59 feet to 46 feet; the figures at the side column show that the lake between these figures gives so many million gallons, which, divided by the daily supply, is 506 days' supply. But it actually runs off in half that time, and the leakage, evaporation, and waste, down as far as Freelands accounts for the difference.

The CHAIRMAN—Do you think anything could be done to increase the supply of water at Vehar?

Mr. ORMISTON—Yes; but not to give us an independent source.

The CHAIRMAN—How do you think the supply at Vehar might be increased?

Mr. ORMISTON—By the Toolsee scheme.

Colonel KENDALL—And also by increasing the height of the dam?

Mr. ORMISTON—We should not increase the height of the dams, it would be a most unsafe thing to do.

Colonel TREVOR—It was intended at one time to raise the level so as to bund up the water.

Mr. ORMISTON—Yes; but it is not required. The fact is the gathering ground and the dams at Vehar have been tolerably well balanced.

The CHAIRMAN—Do you think there might be any attempt to increase the gathering ground?

Mr. ORMISTON—To do so you require to do both—that is, to increase the gathering ground and also the height of the dams.

Dr. HUNTER—The dam would be more likely to burst at the end of a monsoon when the pressure would be greatest. Do you think such a contingency an extra source of danger requiring special provision, more so than in countries where the rain fall is not periodic?

Mr. ORMISTON—You cannot make any temporary arrangement to get a supply for these eight months, and I think, therefore, you would require some stand-by.

Dr. HUNTER—You think that an additional reason for the necessity of an extra supply?

Mr. ORMISTON—Yes.

Dr. HUNTER—You read some extracts from Mr. Hawkesley. You said that the supply in Sunderland and other towns was 10 gallons per head per diem, but according to Professor Parkes' work on Hygiene, in 1852 Manchester received 20 gallons, and Glasgow 35 gallons per head, whereas in 186 Glasgow received 50 gallons per head.

Mr. ORMISTON—Yes; but a great deal of that is wasted.

The CHAIRMAN—Water is greatly required in Glasgow for manufacturing purposes?

Mr. ORMISTON—Yes. At New York they thought they had an inexhaustible supply of water, but they wasted it to such an extent that they found they were short.

Colonel KENDALL—In a town not properly drained there would be more danger in bringing in a supply of water than in a town with thorough underground drainage?

Mr. ORMISTON—A great deal would depend on the nature of the formation on what the town was built.

Dr. HUNTER—In 1857 London received 32 gallons, and in 1862 about 50 gallons per head daily. I merely point out these figures to show the great discrepancy between Professor Parkes' work and Mr. Hawkesley's. Have you taken into consideration the amount required for watering the streets, for fires and fountains, and so on?

Mr. ORMISTON—In Bombay, we find that we have a supply of 10 gallons per head per diem for all purposes, and I think everybody gets as much as he wants.

Dr. HUNTER—Remembering further that water is very much more used by the community here than in England—for I should think the natives use three or four times the quantity that a European would use, in order to keep themselves clean. Then in watering the streets you must require much more in a tropical climate than in Europe. In London, for instance, the streets are watered only two or three times a week; but here for nine months in the year they have to be watered every day, and even then we find it insufficient, so that a much larger quantity is used for that purpose alone.

Mr. ORMISTON—But, as a matter of fact, we find in Bombay that we do with 10 gallons; it is a matter of opinion how much more we should have.

Dr. HUNTER—I see Mr. Crawford, in his report on Mr. Aitken's scheme, says that there is an average of 12 gallons per head per diem.

Mr. ORMISTON—Yes; in a general way. In England 16 gallons is used in non-manufacturing towns for all purposes.

Colonel KENDALL—And that is where there is a general system of house drainage, water-closets, and other appliances which require water?

Mr. ORMISTON—Yes; I have stated very clearly my feeling that the want is not so much on account of scarcity as from the supply being uncertain.

The CHAIRMAN—Do you think the present main from Vehar to Bombay is sufficient to bring the supply down, or do you think there ought to be a second main?

Mr. ORMISTON—There is no necessity for a second main from Vehar, so far as the supply is concerned, for we could deliver much more than we take from it; by doing so we should of course reduce the pressure in the town: thus if it were all drawn off that could be taken there would be no pressure at all in the town.

Dr. HUNTER—Do you think the risk is so much as to justify the expense of getting another main?

Mr. ORMISTON—No; in the event of the main bursting you only lose so much water, and a day or two will put it all right again; but in the case of the dam bursting you are thoroughly smashed.

Colonel TREVOR—Then you think a considerable reduction might be made on Mr. Aitken's estimates by leaving out the main?

Mr. ORMISTON—I should bring the main from Canery to the neighbourhood of Bombay.

Colonel TREVOR—Why should we not join the mains from the two dams?

Mr. ORMISTON—I object to that very much, partly because I think the site of the present Vehar main has been most injudiciously chosen. There is a double risk to run. The main is laid for a considerable distance along the railway, and if an accident should happen by a train running off the line for instance, the pipe might be broken, and if the main burst, which it is more likely to do by night than by day, it would very likely sweep away the railway, and might cause a very serious accident to a train.

Colonel TREVOR—Are you aware of any such thing happening before?

Mr. ORMISTON—No.

Colonel TREVOR—It was broken on the G. I. P. Railway, near Coorla, but the stoppage was only for a day or two.

Mr. ORMISTON—That was my reason for thinking it an ill-chosen line for the main.

The CHAIRMAN—In his report to the Secretary of State, on the best manner of keeping water sweet in tanks, I find Mr. Chadwick says—"The waters derived from subsoil drainage will be in the highest order of purity and quality, cool, clear, and well aërated, and in the best condition for storage in covered reservoirs direct, and without any subsiding tanks." Do you think anything might be done during the monsoon in the way of collecting rain water or water drained from higher parts of the island in covered reservoirs anywhere in the island of Bombay?

Mr. ORMISTON—Not to any extent; you might gather a good deal of water on the Flats.

The CHAIRMAN—Do you think any storage of water on the Flats would be sufficient to guard against an accident to the Vehar dam?

Mr. ORMISTON—I should think not; between evaporation and subsidence it would all be lost.

The CHAIRMAN—Suppose it is kept in covered reservoirs?

Mr. ORMISTON—Covered reservoirs would be very expensive.

The CHAIRMAN—It is the unanimous recommendation of the gentlemen who were consulted by the Secretary of State that the water should be kept in covered reservoirs before being given to the public?

Mr. ORMISTON—I am aware that it is clearer; and also much freer from insect life.

The CHAIRMAN—Mr. Chadwick alludes to a reservoir of 500 acres covered with a roof of hollow brick.

Mr. ORMISTON—A reservoir to hold a month's supply of 8 million gallons per day, if 15 feet deep, would cover an area of 50 acres, and if made as cheap as the cheapest covered reservoir in England (30s. per thousand gallons of capacity), would cost £360,000. In Bombay it would be certain to cost more than would construct the Canery scheme.

The CHAIRMAN—Do you wish, Mr. Aitken, to ask Mr. Ormiston any questions?

Mr. AITKEN—No; I will explain my schemes by and bye.

The CHAIRMAN (to Mr. Crawford)—Do you wish to ask Mr. Ormiston any questions?

Mr. CRAWFORD—I should like to know whether Mr. Ormiston is quite satisfied as to the fact of the present water supply being sufficient. (To Mr. Ormiston)—You have not gone into details.

Mr. ORMISTON—I am not so competent to speak upon the point as other witnesses who will no doubt give evidence. All I know is from Mr. Aitken's table, which shows that the Vehar main is not fully drawn upon.

Mr. CRAWFORD—Are you aware that the supply is intermittent, and that it is necessary to shut off the supply from one-half of the town in order to let the other half get water?

Mr. ORMISTON—I am not aware of that.

Mr. CRAWFORD—That being so, is it not an additional reason for having a fresh supply?

Mr. ORMISTON—Yes; and all corporations now go in for continuous service.

Mr. CRAWFORD—Not only as regards the convenience to towns, but as an additional precaution against fire?

Mr. ORMISTON—Yes.

Mr. CRAWFORD—What amount per head do you think we require in a town of this population; do you think it is at all fair to compare towns in Europe with Bombay; do you not think in this country there ought to be a much larger supply provided?

Mr. ORMISTON—That is what Dr. Hunter was saying.

Mr. CRAWFORD—Not only as a matter of convenience, but also of health?

Mr. ORMISTON—Yes; there is no doubt that we want more for washing and bathing purposes in this country than at home.

Mr. CRAWFORD—Then there is much wanted for irrigation.

Mr. ORMISTON—I believe the rate-payers would willingly pay for water here as they do elsewhere. In Glasgow the capital spent by the Corporation for waterworks has been £1,600,000, for a population of 500,000, and their annual income from that source is £103,000. I think that we are getting water here too cheap. I think it should not be a burden upon the Municipality. With Vehar and Canery your expenditure would still be within a million.

Colonel KENDALL—Are the poor population in Bombay worse off than they are in English towns?

Mr. ORMISTON—Yes; not only the poor, but the whole population on an average is much poorer than in England, and that is the reason you should not have a more expensive scheme than it is absolutely necessary to be safe with.

Mr. CRAWFORD—I gather, from summarising your observations, that you agree with me that Shewla is very well in its way; that if water could be brought in an open canal, it might be a desirable scheme; but failing that, and looking at the matter altogether, you are of opinion that Canery should be taken up first, and if a further supply is necessary it should be supplemented by the Poway scheme.

Mr. ORMISTON—That is my opinion.

Colonel TREVOR—Have you ever gone into calculations as to what the cost of Vehar water is to the public, and what it could be given to the public for?

Mr. ORMISTON—Taking nine per cent. on the original cost of the works and for a sinking fund, and two lakhs for working expenses, you have 7½ lakhs of rupees; the quantity sent into Bombay in a year is three millions of thousand gallons; this would give about 4 annas per thousand gallons as the cost price. I also tried whether it would be profitable to work engines with it, but found it would only give 100-horse power in Bombay, and could not compete with coals.

The CHAIRMAN—We are very much obliged to you, Mr. Ormiston, for the information you have given to the Commission, and we will not detain you any longer.

Mr. ORMISTON—I wish to add that I have assumed that Mr. Aitken's surveys have exhausted the sources of supply.

MR. A. T. CRAWFORD :—

Mr. CRAWFORD—The Commissioners have done me the honour of asking certain questions with reference to the origin of the discussion on the water supply, and in order to save time I should like to make a short narrative of it. The question of the danger of the Vehar Works and the shortness of the supply was first brought forward by Mr. John Fleming in the early part of 1865. He then drew attention to the very great danger of depending upon the Vehar Works as the sole source of supply to Bombay. I imagine at the same time that he must have made a demi-official communication to the Government, for on the 30th of January, some twenty or thirty days afterwards, there was a Government Resolution appointing a Committee, of which Dr. Leith was President. Its report was forwarded on the 14th of July 1865, in which certain recommendations were made; and upon that Government passed a Resolution, requesting that the Bench would take up the matter as soon as possible, and pointing out the necessity of increasing the present supply and taking measures for preserving the continuance of the water supply hereafter. The Bench considered the matter, and I think two months afterwards, at my request, sanctioned the expenditure of a sum of Rs. 25,000 for a survey, with the view of ascertaining if there was any possibility of increasing the water supply in the immediate neighbourhood of Vehar. The survey has been going on ever since, and this report of Mr. Aitken's embodies the result of his labours. The Committee, appointed in the first instance by Government, recommended that a survey should be commenced with a view to constructing catch water drains, and thus increasing the supply of the existing Vehar Lake; but after a survey, extending over some months, Mr. Aitken pointed out that it was doubtful if these catch water drains would increase the supply of the lake: in fact, as Mr. Ormiston had already stated, and conclusively shown, the balance between the area from which the lake is fed and the head of water in the dam is so finely balanced that it is very doubtful if any new catch water drains would add materially to the height of the water on the lake; and on the other hand, these catch water drains would be liable to injury or destruction at any time from the excessive rainfall on those high ridges. Then there was another point upon which the Committee insisted somewhat strongly—that all unnecessary expenditure of Vehar water should be forbidden and that it should no longer be allowed for irrigation and for watering the roads and measures were immediately adopted to prevent this, as far as irrigation was concerned; in fact it is not used for irrigation now, and whatever now goes on in the way of irrigation with Vehar water is done surreptitiously: but as to watering the roads the question of cost has been gone into very closely. Watering the roads in this country is absolutely essential as a matter of comfort and health to the people, and we do not feel justified in abstaining from using Vehar water, for there would be a great additional cost if the water was taken from tanks. We thought also that the Committee had rather over-estimated the amount of water used for watering the roads; and Mr. Aitken, after making close calculations, found that the actual amount was only three per cent of the total amount brought daily into the town, and we therefore decided that the practice should be continued till otherwise advised. The Committee at the same time advised that, when the supply in the existing lake had been increased as far as possible by these catch water drains, that then a second 32 inch main should be laid. As the catch water drains have not been constructed, the proposal to double the main has never been seriously considered. The last recommendation of the Committee was that the capabilities of the valleys between Vehar and Mount Pesir should be ascertained by survey. That has now been done, as the Committee have seen. I simply give this narrative to show how the discussion first originated, what were the suggestions of the Committee appointed by Government, and how far they have been carried out by those responsible for their execution.

The CHAIRMAN—Have you got a copy of the Resolution of Government on the report of the Committee?

Mr. CRAWFORD (handing a paper to the Chairman)—It is here.

Colonel KENDALL—Are there any statements, or papers, with the recommendation that an additional supply of Vehar water was necessary, and that there is a deficiency in the water supply of Bombay; or was that only assumed by the Committee as actually existing? I think I understood you to say that the Committee reported that the water supply in Bombay was deficient, and recommended certain additions and alterations to the Vehar Lake for the purpose of increasing that supply, and also certain arrangements in the distribution, whereby greater economy should be exercised;—did they give their reasons for assuming that the supply to be procured from the Vehar Lake deficient?

Mr. CRAWFORD—They went into the question rather in detail, as you will see from a paragraph in the printed report.

Colonel KENDALL—I have not got that printed report. What is the date of it?

Mr. CRAWFORD—I will get that report taken out and separately printed.

Colonel KENDALL—Yes; it is a very interesting report, and I think it will be of great service to us.

Mr. CRAWFORD—As to the next question put to me, regarding the water supply from the Vehar Lake, I will state, as regards the number of dipping wells, &c., that at present there are 42 dipping wells, 31 drinking fountains, 19 stand pipes, all for public use gratis. From the dipping wells some 312,000 gallons are daily drawn, and from fountains and stand pipes 300,000 gallons, giving a total of 612,000 gallons a day given away free. The number of house connections on 31st December for domestic service was 7,419; connections with mills, factories, &c., with meter, 56; and there were 55 connections with meter from which people irrigated their grounds. The quantity of water used daily for watering the roads was three per cent. of the total daily delivery, or about 240,000 or 250,000 gallons per day.

The CHAIRMAN—Have you got the quantity supplied to mills, and for garden irrigation, by meter?

Mr. CRAWFORD—I could get that if necessary.

The CHAIRMAN—You can give us that, and at the same time the meter readings of the large hospitals.

Mr. CRAWFORD—I can give you all the Government building readings.

Colonel KENDALL—And if you could give us the number of inmates it would help us.

The CHAIRMAN—And also the water gratuitously supplied to hospitals and other places of that kind

Mr. CRAWFORD—Then as regards the next question, as to the cost of maintenance, it is impossible to separate the cost of maintenance from the cost of distribution: the two go together. The same gangs which are employed in distributing the water are also employed in repairing breakages. The cost of maintenance and distribution last year was Rs. 33,758.

The CHAIRMAN—That is about 8 per cent on the revenue.

Mr. CRAWFORD—Yes; taking the revenue at 4 lakhs. Then as regards the number of house connections, I wish to draw the attention of the Commission to the fact that the number is now stationary, thereby indicating very clearly to my mind that we have reached the limit of our distributing power—that we cannot now distribute to the satisfaction of the people in any greater number of house connections. It is also shown, by the numerous applications to have water cut off, that people don't get the water they expected to get and which they are charged for, simply because we cannot deliver the amount. In Elphinstone Circle, for instance, and many other parts of the Fort, people have pipes conveyed up into their houses, and yet they don't get water, and the reason I think is that the area of distribution has increased so largely of late, and the number of connections is so great, that there is not a sufficient pressure to deliver the water. And if the Commissioners will look they will see that at the end of 1867 we actually had more connections than we have now, on account of people requesting their connections to be cut off.

The CHAIRMAN—Yes; there has been a falling off of 107.

Colonel KENDALL—Have you any report from any Engineer or professional man on the question of the non-distributing power, or the inability to supply different parts of the town? Because such a report would be rather useful.

Mr. CRAWFORD—I cannot say I have. The thing seems plain. The extensions during the last five or six years have been immense. All the suburbs have been supplied. Mahim, Sewree, Worlee, Sion, Wudala, Ghompdevie, and other outlying places have been supplied, and at the same time the number of connections have been increased.

The CHAIRMAN—Is there any Engineer in special charge of the Water Works now?

Mr. CRAWFORD—Yes.

The CHAIRMAN—Can you get a report from him?

Mr. CRAWFORD—Yes; and I have no doubt Mr. Aitken could give you very valuable evidence as to that.

Colonel KENDALL—But I suppose there would be no engineering difficulty in having a main at Sion, and even if it were necessary a pump to force water, or a syphon, to bring the water to a higher level?

Mr. CRAWFORD—We have not sufficient water to charge our present system of mains; the amount of water brought down is not sufficient; and if we brought down more water by another main, we should run the lake dry in two consecutive dry seasons.

Colonel KENDALL—The pressure is not sufficient.

Mr. RUSSEL AITKEN—There is not enough water in the lake. The lake only overflows the waste weir once in three years, so that we have no water to spare from the lake. If it was in the lake there would be enough for distribution. We take all the water from the lake which we can take safely.

Mr. CRAWFORD—I propose to put in a map showing the different sluices from which the town is supplied—(produced map; and explained to the Commissioners the hours at which the different sluices in various districts of the town were opened and shut) —so that in consequence of the shutting off, two-thirds of the native town is without water during the night; and during the day the mains, instead of being charged as they should be, are, at least many of them, only dribbling. Now, when the late conflagration broke out at the Post Office, there was only a dribble of water in the pipes, and in order to get a supply for the steam fire-engines a man had to run to Pydownee and close off the water then flowing to another district. You will see that the danger of this system is very great indeed. To show what can be done when the main is properly charged, I would instance the fire which occurred last night at Bholeshwur, just by the large temple. The head turncock lived close by, and at once opened the 19 inch sluice, and got on the water which was running to Colaba, and the consequence was that the fire was easily put out in half an hour by hoses fixed to the street hydrants, which gave a pressure of 90 feet at once, so that when the fire-engines came they were sent home again. Had we had a similar supply at the Post Office, in all probability the Post Office would have been saved. I beg the Commissioners to understand that I dissent very strongly from Mr. Ormiston when he says that the present water supply is considered quite sufficient by the people. I think it is important that some independent evidence should be taken on this point from those acquainted with the town.

The CHAIRMAN—I believe you receive many complaints from many parts of the native town in consequence of the insufficiency of the supply?

Mr. CRAWFORD—Yes; and many people have their connections cut off in consequence. The number being cut off are now in excess of the applications for connections.

Colonel KENDALL—It would be useful for the Commission to know whether that is owing to original defects in the pipe and whether there is sufficient water in the lake for Bombay; or whether the deficiency is due to the way in which the water is distributed. The Commission would be guided regarding that by a professional report.

Mr. RUSSEL AITKEN—I think I can give you that in my evidence.

The CHAIRMAN—Then, Mr. Crawford, you adhere to your opinion, expressed in your report on Mr. Aitken's schemes, that the present supply should be at least doubled?

Mr. CRAWFORD—Yes.

Colonel KENDALL—Do you think it would be all consumed?

Mr. CRAWFORD—Certainly. Of course there would be a considerable amount of wastage, but you must remember that in this country the habits of the natives differ entirely from those of Europeans. For instance, they bathe in the open air, and waste a great deal of water in that way.

Colonel KENDALL—And if you had double the quantity you have now, the wastage would be enormously increased. Do you think that would be the cause of any disease or of any undue dampness of the ground?

Mr. CRAWFORD—On the contrary I think it would be easy to obtain evidence from scientific and native gentlemen, who will tell you that the fact of there having been so much more water in Bombay since the Vehar works were opened has contributed materially to the health and improved the climate of Bombay. Though of course if you were to swamp the place, without providing surface drainage, sickness might result.

Dr. HUNTER—Do you think watering the roads has any effect on the health of the people?

Mr. CRAWFORD—Certainly.

Dr. HUNTER—Good or otherwise?

Mr. CRAWFORD—Good.

Dr. HUNTER—On what grounds do you base that opinion?

Mr. CRAWFORD—On the opinion of Dr. Leith and others, and on my own experience.

Dr HUNTER—And you think that watering the roads in a tropical climate is conducive to health?

Mr. CRAWFORD—Yes; because the dust inhaled contains much that is deleterious, and is infinitely more injurious than the effects of the evaporation of water. There can be no doubt as to the comfort of the thing.

Dr. HUNTER—What would be the effect of sea water upon the roads?

Mr. CRAWFORD—It makes them slippery, but they keep damp for a greater length of time.

Dr. HUNTER—But what is the objection to using sea water?

Mr. CRAWFORD—Because it is so expensive. It involves the lifting of every gallon by hand labour or steam power. Formerly the roads used to be watered partly by sea water—some six years ago.

Dr. HUNTER—I have no doubt sea water would be more useful than fresh water.

Mr. CRAWFORD—On the other hand it was contended by Dr. Leith that the use of salt water was in itself prejudicial to health.

Dr. HUNTER—Yes, I know; but in many places they use it now.

Mr. CRAWFORD—Yes; and they have in England invented some saline mixture for road-watering to make the roads retain moisture. If it would pay to construct lifting apparatus for the sea water it ought to be done at once, for it would save 250,000 gallons of water daily.

Dr. HUNTER—In renewing the roads, for instance, do you find the subsoil wet or dry?

Mr. CRAWFORD—That depends on the place and also on the season. Of course in the monsoon the earth is wet close to the surface.

Dr. HUNTER—I refer to the dry season. Do you think the water percolates through?

Mr. CRAWFORD—It is simply wet on the surface for a very short time, the evaporation is so rapid.

The CHAIRMAN—Supposing you gave the people 20 gallons a head a day at Camateepoora, where there is a poor population living in a low-lying part of the island, don't you think the wastage of water there would have a prejudicial effect on the death of that part of the community?

Mr. CRAWFORD—It might be if the district were not drained, but Camateepoora has now been drained; now the wastage would simply go off into the sewers, and that would obviate any difficulty.

Colonel KENDALL—It would depend on the drainage arrangements, and what you say depends on the drainage being complete.

Mr. CRAWFORD—Surface drainage and an increased supply of water go hand in hand.

Dr. HUNTER—Don't you think tank water might be used for wetting the roads?

Mr. CRAWFORD—There is only one objection to using tank water, and that is the expense of lifting it. For the same money which we spend now in getting 100 or 110 water carts of Vehar water we could not possibly get more than 50 carts for tank water. Now the watering of the back roads is even more appreciated by the natives than even lighting the streets.

The Commission then adjourned till Monday, the 22nd, at 2 o'clock, in the Town Hall.

SECOND DAY. MONDAY. MARCH 22.

The following Commissioners were present—

ANDREW R. SCOBLE, Esquire, *Chairman.*
Colonel KENDALL, R.E. | Dr. HUNTER.
Dr. LYON, *Secretary.*

The Commission resumed at 2 o'clock on Monday, in the Durbar Room, Town Hall.

CAPTAIN TULLOCH, R.E. :—

The CHAIRMAN—Have you read Mr. Aitken's report on the extension of the Bombay Water Works ?

Captain TULLOCH—Yes.

The CHAIRMAN—Will you favour us with your opinion as to the various schemes mentioned in that report ?

Captain TULLOCH—Before going into the general subject of water supply I should like to say a few words upon Mr. Aitken's projects. I will not go into the Poway and Toolsee schemes, because the general impression appears to be that they will not be considered, and the matter therefore seems to hinge upon the acceptance ofeither Shewla or Canery schemes. Taking the Shewla scheme : the main feature of this is that there is to be a reservoir about 56 miles from Bombay, with a dam 96 feet high and a supply channel 56 miles long ; that channel is to be under pressure the whole way. Instead of having a cast iron pipe it is proposed to use a steel one : that has never been tried before, and, though I am not at all opposed to a new material being introduced, it will at all events be an experiment, and rather a costly one if it turns out a failure. The cost of the work, according to Mr. Aitken, is to be 140 lakhs, but when Mr. Ormiston went into the subject the other day he said that he was under the impression that the Shewla scheme would cost not 140 lakhs but two millions sterling. I had gone into the subject of the cost before Mr. Ormiston gave his evidence, and came to the conclusion that it would come to above 180 lakhs, so that Mr. Ormiston and myself were not far out ; there was only a difference of 20 lakhs. [Mr. Aitken here handed a paper to Captain Tulloch.] Mr. Aitken has no doubt handed me this paper to draw my attention to the cost of steel, but it is not with reference to that only. Although the cost of steel will certainly be in excess of what Mr. Aitken has put it at, though I do not think it will be as much as Mr. Ormiston has said ; but the cost of carriage will be very much more, and the cost of laying it still more. At all events the mere fact of Mr. Ormiston and myself coming to the opinion that the estimate will be about two millions is presumptive that we are more likely to be correct than Mr. Aitken. But taking the scheme at 140 lakhs, the cost is in excess of what the project is worth, because for 140 lakhs it ought to be a very much better one, and there ought to be no such thing as risk. The Shewla project depends entirely upon its success on the safety of one pipe 56 miles long and three-eighths of an inch thick. Now 56 miles of piping with a pressure of 300 feet is really a very serious thing, and if anything does happen very serious consequences might arise, though at the same time I think there is no reason why the pipe might not stand ; but, taking the risk into consideration, I do not think the project is worth the sum which has been set down. A town as large as Bombay should not be dependent for its supply upon a pipe involving such a risk as that. That is all I have to say with respect to the Shewla project.

The CHAIRMAN—Let me ask you if you think the pipe should be half an inch instead of three-eighths of an inch thick ?

Captain TULLOCH—I presume you refer to the steel pipe ?

The CHAIRMAN—Yes.

Captain TULLOCH—Steel is a new material altogether, and I very much doubt if we have anything like satisfactory experiments to prove what the strength should be. I know of no case of steel pipes having been used for water works. Mr. Ormiston said the other day, and I was very much surprised to hear it, that the strength of steel was really not more, or that its strength could not be depended upon more than wrought iron : and that is a very serious thing indeed.

The CHAIRMAN—Mr. Ormiston supported his assertion by quoting from a recent work on steel by Mr. Reed, the Constructor for the Navy.

Captain TULLOCH—If Mr. Reed, the Constructor of the Navy, has said so, I presume he is right, for no one can have had more experience of the subject than Mr. Reed, and his opinion very much detracts from the value of steel. I may say that I have not seen Mr. Reed's work myself.

The CHAIRMAN—As to the amount of pressure that a main should be able to stand, do you agree with Mr. Ormiston that it should be the same as a locomotive, 140 lbs. to the square inch ?

Captain TULLOCH—I have not gone into that, but it is easily calculated ; most probably Mr. Ormiston took the pressure from a table in which the strength of steel mains under different pressures is given. I have not got it in my head, but that information you could get from any engineering book. I have not brought any with me, but I could do so at the next meeting. Three-eighths of an inch for a main 4 feet 6 in. in diameter seems small ; and 300 feet of pressure is a very serious thing. The pipe might stand, but there might be a flaw, and then the worst consequences might arise. Another eighth of an inch would add very materially to the weight of the pipe.

The CHAIRMAN—As to bringing down the water from Shewla in an open duct, and then bringing by piping into Bombay, what do you think of that idea ?

Captain TULLOCH—I will come to that question further on ; and then if you have any questions to ask on that subject I will answer them. Shewla, in my opinion, is not well situated for water works of the description Mr. Aitken contemplates ; it is too far from Bombay, and by going so far away you derive no advantage, as far as I can see, and the ground to be passed over, in my opinion, is not favourable. It is 56 miles away—at least I measured it on the map, and made it 56 miles. I don't know, but I presume Mr. Aitken has got the survey of the line that the main is to take. I have not seen that survey, and therefore I cannot test it ; but an apparent length of 56 miles traced on a plan of two miles to an inch will be at least six or seven miles longer in reality, because each of these valleys that you see on this map will probably consist of three or four smaller valleys, so that the contour, instead of going in this fashion (pointing to the plan) will go in and out still more, and that is what makes the length of the conduit very much more in reality than it would appear on the plan. I measured the pipe from the plan. This is the valley (pointing to the plan), and I measured the distance along here, but then it is quite possible that there may be many places where you could not take it in that direct way. Aqueducts and other works might be required, and that might make the work more expensive than it appears at present. With regard to the Canery project, the principal features are, a reservoir about 22 miles from Bombay, a main of cast iron 32 inches in diameter under pressure the whole length, and a dam about 136 feet high. The total cost of this project is to be about 41½ lakhs, of which 17½ lakhs is for the dam and 24 lakhs for the pipe. I forgot to draw your attention to a very important point with regard to the Shewla scheme. If you look at the estimate for the Shewla reservoir you will find, taking Mr. Aitken's figures, that the dam costs nearly 15 lakhs, while the pipe costs 125 lakhs ; that is to say, the works of the reservoir don't cost one-eighth of the pipe ; but taking Mr. Ormiston's figures, the dam will cost about 15, lakhs, and the main 185 lakhs—that is to say, more than twelve times as much as the works of the reservoir. Now, with regard to Canery, the proportion is 17½ lakhs for the dam and 24 lakhs for the pipe ; but in this case the cost of the dam is more in proportion than in the case of Shewla, because the dam, instead of being 96 feet, is to be 136 feet high. My general opinion with regard to the Canery project is that it is not worth the sum of money proposed to be expended upon it, however good the project may be in itself. Now what will be got for it ? The present supply from Vehar is 12 gallons per head per day, but the effective supply is not more than half that. One of the chief axioms in water works engineering is that the first purpose for which water is required in a town is for waste, and then come all the other purposes. Now, from the Canery project we shall only get 6 gallons more than we do at present, allowing six gallons for waste, which I am sure it will amount to in this country. There are towns in England where, though the fittings are particularly well put up, the waste is considerable ; but in this country, where the fittings cannot be equal to those at

home, I am certain I am not overstating the amount when I say that the waste is one-half. Even in the house in which I live at present, I find constantly that the tap is running all night. Not only is the huge tub that I have quite full, but three or four tubfuls must go to waste during the night. If that occurs in one house, we may be perfectly certain it occurs in many more.

Colonel KENDALL—You say that half the water is wasted. Do you mean that half the water is wasted before or after it comes to Bombay?

Captain TULLOCH—I take six gallons as the waste out of the twelve that comes into Bombay.

The CHAIRMAN—That is, that one half is wasted in the course of distribution from defective joints, taps kept open and running all night, and that kind of thing?

Captain TULLOCH—Yes; and it is the same at home; you constantly see a watercloset tap running for hours and hours. My father's house was regularly flooded with water one day simply from a tap on an upper floor not having been turned off. Mr. Aitken's estimate for the Canery scheme is estimated to cost 41½ lakhs, but Mr. Ormiston said at the last meeting of the Commission that in his opinion the scheme would cost 50 lakhs. I think it would cost 60 lakhs; but taking Mr. Ormiston's as the mean between Mr. Aitken's and my estimate, I do not think that the Canery project is worth that sum. In the first place we have to build a dam 136 feet high, which would be a most dangerous work, and then we should have twenty-two miles of piping, all under pressure. I do not contend that a dam could not be constructed of that height perfectly safe, but what I say is that no work costing half a million of money should depend for its success on a dam as high as that. The Municipality risk £500,000, or at all events if not the whole of that a good portion of it, and if an accident happened, in addition to their own loss, they would have to pay something frightful for compensation. The railway runs at the bottom of the valley, and there are also villages there, and if the dam gave way it would be a very serious thing. If you had two or three reservoirs, and one could be saved if the others were destroyed, it would be a different thing; but by Mr. Aitken's plan all depends upon the stability of one dam. I have been over the Manchester and the Glasgow works. There is a very false impression abroad with respect to the Manchester Works. Mr. Aitken says himself that the highest dam he is acquainted with is 114 feet high. I presume he refers to the Manchester reservoir. (To Mr. Aitken)—Is that the case?

Mr. AITKEN—I forget which it is now.

Captain TULLOCH—If I might be allowed to ask Mr. Aitken a question;—to what height has he ever seen that dam full?—That is the question with regard to the Manchester Works. The dams were I thought 110 feet high; I did not know that the highest was 114 feet, and I think Mr. Aitken is mistaken with regard to that. And then they go down to 90 and less than that; but this 90 foot dam is never full to within six feet of the top. There would be the greatest risk in filling the dams to the height up to which it was originally intended to fill them.

The CHAIRMAN—To what height do you think the 136 foot dam could be safely filled?

Captain TULLOCH—That would depend upon the construction of the dam; you might fill it to within 10 feet of the top; say to 126 feet.

The CHAIRMAN—Supposing it necessary to build a dam 136 feet high, in what proportions would you construct your dam in order to ensure safety?

Captain TULLOCH—It is a very simple rule. They give a large slope on the inner side—3 to 1 you may take it for a large dam of that kind. The dam should be 30, 40, or 50 feet wide at the top, with a back slope of about 2½ to 1. The puddle wall will begin at the top, and for such a large dam as that you must make it 15 feet wide, with a slope of 1 in 10 or 1 in 12 going down to the ground. Here (showing a plan) is the whole construction of the reservoir.

The CHAIRMAN—Do you think that the inner facing of the dam should be puddled also?

Captain TULLOCH—That would be a very good thing, and it has been proposed before now, especially in a work I see lately written by a gentleman of the name of Jacob, who had been in this country for some time. The idea is not new, for I believe it has been done in many cases.

The CHAIRMAN—It would have the effect of strengthening the dam materially, I suppose?

Captain TULLOCH—Yes, in preventing the water passing through.

The CHAIRMAN—I do not, of course, mean a mere mechanical resistance. I suppose it would be a considerable additional expense?

Captain TULLOCH—No; I don't think it would be a very serious additional expense at all. It would add something, but not very much.

The CHAIRMAN—Then you think the slope of a dam such as this should be 3 to 1 and the inside 2½ to 1, in order to secure the proper strength?

Captain TULLOCH—I am not prepared to say that. I only give you that as an example of how

dams are constructed at present. I don't agree with the generality of engineers on the construction of dams, for I think they put too much material in front and not sufficient behind.

The CHAIRMAN—Then, according to your opinion, what ought to be the proportion in this country?

Captain TULLOCH—That would depend very much upon the natural slope of the earth of which the dam is to be made.

The CHAIRMAN—But supposing you yourself had to build a dam for this Canery reservoir, have you at all considered the form in which you would build it?

Captain TULLOCH—I have not considered that. I do not know what the soil is.

Mr. AITKEN—It is red earth.

Captain TULLOCH—Yes; but at what angle does it stand?

Mr. AITKEN—1¼ to 1.

Captain TULLOCH—Wet?

Mr. AITKEN—Dry.

Captain TULLOCH—But wet?

Mr. AITKEN—I should think it could not stand at that.

Captain TULLOCH—Well, I can't say. Certainly for a large dam I would do as you mentioned just now—put a puddle bank facing the water just behind the pitching. Undoubtedly that is a very good plan.

The CHAIRMAN—Do you think that if Mr. Ormiston's idea of having a berm of 20 feet inside and 50 feet outside were followed out it would be a material addition to the strength of the dam?

Captain TULLOCH—I should go in for a dam very much stronger than what would be considered necessary under ordinary circumstances, for the risk here would be something frightful. There is no dam as high as that, and we know nothing about water under so great a pressure as that in large reservoirs. The mere fact of the Manchester dams never being filled to the height it was intended to fill them shows at all events that great care is taken of them. I have not seen any of the Manchester dams filled to anything like the proper height, and when I went over the works I was told that they never were filled to the proper height. If one of the Manchester dams burst it would be a most serious thing—especially if the big one at the top went, for then all the rest would go like a pack of cards. At the same time it should be remembered that when the Manchester reservoirs were constructed, so much was not known about the construction of large reservoirs as at present, and the construction of dams now is very much improved indeed. I saw them making one of their new reservoirs at Manchester, and they were putting in the puddle with the greatest care, and not only that, but they were preparing the ground for half a mile on either side of the dam right up the reservoir, to guard against fissures, because if a fissure occurs near the dam it may go on for half a mile along the valley

Mr. AITKEN—What strata was it? Lime stone, was it not?

Captain TULLOCH—I don't remember just now, but I remember that I saw them puddling it on both sides. I was there with the Engineer of the works. I think they were Mr. Hawkesley's works. He was the Engineer, but I was not there with Mr. Hawkesley, but with the Resident Engineer. Another objection which I have to Mr. Aitken's projects is that they are not given in sufficient detail. Mr. Aitken has given the totals, but he does not give the length, breadth, and depth of his works, and therefore it is utterly impossible that we can judge of the size. [Mr. Aitken here produced some plans.] Yes; these are plans, but they have not been placed at our disposal. May I ask when they were prepared?

The CHAIRMAN—They were produced at the last meeting.

Mr. AITKEN—They were prepared some time ago.

Captain TULLOCH—But the plans should be put before the public in such a form that people might be able to check them. Now, take this first item in your estimate: If you will show me how it is possible to calculate that from anything you have given us, I will admit myself wrong.

Mr. AITKEN—Mr. Ormiston had no difficulty in doing it.

Captain TULLOCH—Will you show me how you do it? Mr. Ormiston has taken your *totals*, and merely criticized your *rates*.

Mr. AITKEN—Mr. Ormiston told me that he had gone over them and had had no difficulty in checking them.

Captain TULLOCH—Why have you not given the length, breadth, and depth of the works?

Mr. AITKEN—There are very large cross-sections if you wish them now.

Captain TULLOCH—When were they prepared? I have had no opportunity of going over them.

Mr. AITKEN—They were in the office. You could have had them if you had wished.

Captain TULLOCH—There is no survey of the line the pipe is to take, and therefore it is impossible to say whether the length is 56 miles or 70 miles.

The CHAIRMAN—I should like to proceed at present upon the basis that these calculations have been correctly made.

Colonel KENDALL—Yes ; I think we should presume that.

Captain TULLOCH—You then assume that the totals are correct ?

Colonel KENDALL—Yes. It is an abstract estimate, and that is all the Commission is supposed to deal with.

Captain TULLOCH—At the same time I think there would be no harm in giving the length, breadth, and depth of the works. Every estimate is given in detail in my Drainage Report, except in one single item, so that you can get the length, breadth, and depth of the works in the report.

The CHAIRMAN—Yes, it would be a great advantage indeed; but what we have to do with here is, after satisfying ourselves that some one of these schemes is possible in an engineering and also in a financial point of view, to recommend its adoption—the working out will be a matter of detail to be gone into afterwards.

Captain TULLOCH—I think it is very important for a water supply scheme that the geology of the district should be carefully delineated on the plan. Otherwise you cannot tell whether the project is really feasible or not. There is a leak in the Vehar Works which has been going on for five or six years. Can anybody say that that is not due to a fault in the strata? In the water supply plans prepared by engineers at home, the geology of the district is given by a geologist, so that there can be no mistake about putting down the dam on a strata through which the water will pass.

Dr. HUNTER—I understand the geological formation of the ground has been enquired into before the scheme was put before the Commission.

Captain TULLOCH—The general formations are all primitive, so far as I understand; but still there may be a fault. The peculiarity of the geology at the precise spot where the dam is to be placed should certainly be given.

Mr. AITKEN—In all instances trap is the foundation.

Captain TULLOCH—Yes; but how do you know that there is not a fault ?

Mr. AITKEN—Well, I cannot look further into a millstone.

Captain TULLOCH—Then you cannot say that the Vehar is not leaking through a fault. In fact, it has been suggested before now that it is leaking through a fault. It is impossible for you or for any one to say to what, under these circumstances, the leak is due. Looking to the map of Bombay, I think that there is not one place in fifty that is so admirably situated for a water supply as Bombay is. I never saw such a large extent of hill country in the neighbourhood of a large town, where the rainfall was so enormous, and where the rain so seldom failed. Here (pointing to the plan) is Bombay; and here is a huge area all intersected by valleys, in which the rainfall is 300 inches. I believe it is very seldom indeed, at all events on the Ghauts, that the monsoon utterly fails. Under these circumstances I think it would be very strange if a good site for a reservoir were not to be found. Mr. Aitken has gone 56 miles from Bombay, and has selected Shewla, but I think he has gone needlessly far. The cost of the Shewla project is very great, and the amount of water is not, I consider, sufficient for Bombay. We cannot have too much water for Bombay. In India, water means cleanliness, and certainly cleanliness means health. Instead of stinting people of their supply, I would induce them to use as much as possible. They cannot have too much.

The CHAIRMAN—I don't quite reconcile that with your saying that the expenditure of 41½ lakhs would be too much for an additional 12 gallons a day per head.

Captain TULLOCH—I think a much larger reservoir could be got for a very much smaller sum. Just take a glance at the map. Here is the small area that drains into the Shewla—I don't know how many square miles it is.

Mr. AITKEN—26 square miles.

Captain TULLOCH—By coming down the valley lower, instead of 26 you get 100, 200, or 300 miles; and much lower down will impound a very much larger quantity of water.

Colonel KENDALL—I don't quite understand your argument. Do you mean——

Captain TULLOCH—The slope of the hill is so great, that in order to impound a large quantity of water, you must raise your dam 90 or 100 feet high—that is, if you go to the top of the Ghauts; but if you go lower down, you don't require a dam of such a height.

Colonel KENDALL—Then what would be the width of the dam ? Do you see any suitable sites ?

Captain TULLOCH—I think it would be extraordinary if there were not a suitable site. Taking this map as correct, there are valleys here where a dam of about half a mile long would impound I don't know how much water. Some of the hills in these valleys nearly meet the hills on the opposite side.

The CHAIRMAN—At what point is that ?

Captain TULLOCH—All down the valley to Moorb, where the two rivers join. The dam there I do not think would be so long as the dam at Shewla—I am only presuming that this map is correct. There we have a drainage of an enormous area, and the dam would be a much lower one and a very much safer work.

Colonel KENDALL—Then your idea is to get some other site nearer to Bombay ?

Captain TULLOCH—Yes, much nearer to Bombay. I would have a reservoir five, six, or ten times as large as Shewla ; and having that, you would not, every time you wanted an additional ten gallons of water, have to go to the expense of another reservoir and another main. Construct this large reservoir—the nearer to Bombay the better—and have a duct to Bombay—right into Bombay if you can—and pump the water up there. Once having got this work completed, if you wanted any extra supply of water, you would have only to let an extra supply into this conduit, and then you would have the extra expense of pumping into Bombay, which would be about 12 or 13 lakhs for every ten million gallons raised 100 feet high.

Colonel KENDALL—Your argument depends entirely upon whether a suitable site can be got for a large dam. You would require a further examination of the country.

Captain TULLOCH—I would have a report upon every one of these valleys. I have never seen a country intersected with anything like such a number of rivers.

Colonel KENDALL—Do you think it will be necessary to go beyond the island of Salsette ?

Captain TULLOCH—That I can't say—I have not been able to go into the question ; but before you spend half a million of money it is very necessary to ascertain and think whether £600,000 or £700,000 would not give you a much more complete scheme.

Colonel KENDALL—Yes, I see.

Captain TULLOCH—At present, if you go in for the Canery scheme, it will cost you half a million ; and then when you want an additional supply the next scheme will cost you another half million, and so on ; and in the course of twenty-five or thirty years, you will have spent something like three or four millions on the water supply of Bombay ; whereas if you at present make a large reservoir and draw the water through a duct and pump it into Bombay, then whenever you want an extra supply you have only to put on another engine to raise the quantity of water required.

Colonel KENDALL—You mentioned that you would bring in the water from the reservoir by an open conduit.

Captain TULLOCH—I don't say the thing should be done, but I say the subject should be most carefully gone into—the question of an open duct, and a large reservoir much nearer Bombay.

Colonel KENDALL—But setting aside the question of a reservoir, if you come to the question of an open masonry duct or an iron main, what advantage would there be in a masonry duct ?

Captain TULLOCH—You could get an enormous channel for the same sum of money.

Colonel KENDALL—Do you think the water would deteriorate in an open duct ?

Captain TULLOCH—No ; considering that the Glasgow water works are carried most of the way in a close conduit ; but that is all lined with masonry.

Colonel KENDALL—Then it is closed, and has merely air shafts ?

Captain TULLOCH—Yes.

Colonel KENDALL—Have you any idea what would be the cost per mile ?

Captain TULLOCH—No ; I know the total cost of the works only.

Colonel KENDALL—Do you know whether the cost would be more than that of a large main ?

Captain TULLOCH—It must have cost less, as Glasgow is the district for iron. There is no place in England where you can get iron castings so cheap as in Glasgow, and if the iron pipe had been cheaper you may depend upon it they would have used it there instead of what they did use—a masonry conduit.

Colonel KENDALL—You are not speaking from any certain knowledge that a masonry conduit is cheaper—that is only your supposition ?

Captain TULLOCH—I have not got any positive knowledge, but I can give you Mr. Gale's report

on the water supply of Glasgow. It must be cheaper, because, especially in engineering projects, the cheaper a scheme is, the sooner it is sanctioned. (Explaining Mr. Gale's report)—It is only where they have crossed valleys that they have used iron. The reason why I advocate a large duct is that for a very small sum you can build such an enormous one.

The CHAIRMAN—Do you think an open conduit safe in a country where there is such an enormous fall of rain in the monsoon?

Captain TULLOCH—Wherever you have valleys you should make proper arrangements for letting off the surplus water.

The CHAIRMAN—The line of country from Callian to Bombay is quite flat, and it would be covered with water during the monsoon.

Captain TULLOCH—You might probably be able to run a main along the ridge of the lower hills.

The CHAIRMAN—But after you get to Callian there are no more hills.

Captain TULLOCH—Wherever the pipe passes these channels you would have to make proper arrangements.

The CHAIRMAN—But supposing you had a conduit passing over that flat country, where there is an enormous rain-fall in the monsoon, would not you require to arch it over in order to prevent its being swamped altogether?

Captain TULLOCH—We have lots of irrigation channels in the country constructed in the same way—for instance, the one from Kurnool, that is partly an excavation and partly an embankment.

The CHAIRMAN—Then you would require to have a large reservoir in Bombay, and filter the water when it reaches the city if you had an open channel. Where would you filter it? You must filter it in Bombay or just outside of it.

Captain TULLOCH—That would depend very much upon the levels.

The CHAIRMAN—After carrying it here in an open duct in this way you would require very careful filtering before the water was fit to be distributed.

Captain TULLOCH—I do not say that even an open duct would be necessary. We might have a closed one, just as they have in the Glasgow Water Works. But that subject also must be gone into. Taking the distance from Callian to Shewla at about 25 miles, the cost of that portion of pipe would be £900,000, or say, £800,000. Mr. Ormiston says that the pipe would cost £1,850,000 from Shewla to Bombay, and the reservoir would cost £150,000; and according to Mr. Aitken's figures the pipe would cost about £1,250,000.

The CHAIRMAN—37½ lakhs.

Captain TULLOCH—I beg your pardon, the pipe would cost a million and a quarter of money.

The CHAIRMAN—According to Mr. Aitken's calculations it would be £375,000.

Captain TULLOCH—But you must add all the other expenses, such as 9½ lakhs for tunnelling and piping, and also the cost of the ground, which would be Rs. 100 an acre. You must deduct this from the total estimate, and the balance for the pipes would come to 125 lakhs.

Colonel KENDALL—What is the cost of the duct of the Loch Katrine Works?

Captain TULLOCH—The works of the Loch Katrine aqueduct are 25¾ miles long, and cost 47 lakhs, or £468,000.

Colonel KENDALL—The Croton aqueduct cost something like £70,000. The main was brought at a very high level into New York, but the ground here is peculiarly unsuitable for bringing in water in an aqueduct, because the ground is very low-lying.

Captain TULLOCH—I have not seen the report on the Croton aqueduct: I wanted to get it; but I don't know where it is to be had.

Colonel KENDALL—I will look for it. It is sure to be in my library.

Captain TULLOCH—The usual practice at home is to bring the water within ten or twelve miles of the town and then deliver it under pressure.

The CHAIRMAN—Then they have a large reservoir in the neighbourhood of the town?

Captain TULLOCH—No. The reservoir farthest from Manchester is from twenty to twenty-five miles, but you don't bring it under pressure from the first reservoir.

The CHAIRMAN—I think the modern theory is to have a large covered reservoir in the immediate neighbourhood of the point of distribution?

Captain TULLOCH—No; that has been given up. The practice now, and especially in the London Water Works, is to pump direct from the engines without anything but an air vessel.

The CHAIRMAN—It appears that all the London Companies, except two, have covered reservoirs of large area from which they distribute.

Colonel KENDALL—I think you stated that you would bring water by an open duct from the large reservoirs to some place near Bombay where you would put it into a reservoir, and from there you would have a pump for forcing it through the mains and the different distributing pipes?

Captain TULLOCH—Yes.

Colonel KENDALL—Have you considered what style of aqueduct you would use?

Captain TULLOCH—It all depends. It would take a good six or seven months' hard work to determine that.

Colonel KENDALL—I am talking generally. Assuming that there is a large reservoir somewhere within a certain distance—I am merely talking of the probability of making an aqueduct from this district—I would just like to have some rough idea of the cost and style of the aqueduct you would use, and also the exact locality in which you would have the reservoir and pumping machinery to be used for distribution.

Captain TULLOCH—I could not answer that question, because in the first place if I had to work out such a problem as that, I should have to devote weeks to it.

Colonel KENDALL—I am not asking you to select any place, but you know you have to cross the low-lying valleys and also to cross that tidal creek at Tannah, then cross Salsette, and again cross the tidal creek at Bandora. The question would be, coming along at this level, what style of aqueduct you would propose, and also, in what locality you would have the reservoir—whether in the island of Bombay, or in the island of Salsette?

Captain TULLOCH—No; I have no intention of having it in Salsette. I do not think the thing can be done.

The CHAIRMAN—You would have an impounding reservoir on the slope of the hill?

Captain TULLOCH—Yes; and I would carry the water down by a conduit to Bombay. I should not require a reservoir in Bombay.

The CHAIRMAN—Do you not think it would be an absolute necessity in a scheme of this kind in which you would collect water 20 or 30 miles away and bring it down the greater part in an open duct, through flat and marshy land, that you should have a reservoir in the immediate neighbourhood of Bombay for holding one or two days' supply, and to filter it, so as to make it fit for distribution?

Captain TULLOCH—I do not see the necessity for having a reservoir to contain more than two or three hours' supply in such a large town as this. You would require many engines, but it would be an impossibility for them all to break down at the same time.

The CHAIRMAN—In reference to what you said as to a covered reservoir, the most recent Act of Parliament on the subject requires that all reservoirs within five miles of St. Paul's should be roofed in, unless the water is filtered after leaving the reservoir; and, in consequence of that, some of the London Companies have provided reservoirs to a very large extent. The New River Company has a reservoir of three and a half acres, the East London Water Works Company two and a half acres, and so forth.

Captain TULLOCH—I do not think that information is very reliable.

The CHAIRMAN—But it agrees fully with the information supplied by all the scientific men who were consulted by the Secretary of State, and who all advocated such a plan. Mr. Chadwick, for instance, says—"I was led to conclude that the right treatment of the water for the population was to collect it as soon as possible in covered reservoirs by covered channels." Then Mr. Rawlinson says—"All open tank waters, without any exception, should be sand-filtered, and be stored in covered tanks, or passed direct into the supply mains for use." And all the gentlemen who were referred to say the same thing. Dr. Sutherland, of the Army Sanitary Commission, says—"Practically, a covered filtered water cistern or tank capable of containing a day's supply of filtered water for the population would be a necessary adjunct to all works of water supply."

Captain TULLOCH—That depends. If you are going to pump the water immediately after filtration you do not want any reservoir at all.

The CHAIRMAN—Then where would you filter the water?

Captain TULLOCH—I am supposing that you did filter; if you did not filter, and brought the water in a closed duct, a very small reservoir would be sufficient for all purposes.

The CHAIRMAN—And that should be at the point where the pumping engines were?

Captain TULLOCH—Yes; the nearer Bombay the pumping engines were the better it would be, for you would then get the pressure direct in the mains, and you would have no loss of pressure.

Colonel KENDALL—Could you give us any idea now, roughly speaking, of what height the dam would be, and at what level?

Captain TULLOCH—I should say 50 feet at the outside. I speak very generally, of course; the risk of such a dam would be nothing.

Colonel KENDALL—I am talking of the aqueduct.

Captain TULLOCH—That I could not say. It is impossible. It depends on the height of the reservoir. I do not know the level of the different parts of the country.

Mr. AITKEN—The ground is quite level, only about 5 feet above the mean sea level all the way.

Captain TULLOCH—But I must know how much water a dam 50 feet high would impound.

Mr. AITKEN—Suppose you got it, how would you bring it down over that flat country?

Colonel KENDALL—Yes; that is the question. That is what I want to know. There is a certain low-lying district of country between Salsette and the valley, where the reservoir must be found; and the question is, how would you get over that ground? what would be the height of the aqueduct required to carry it over this ground?

Captain TULLOCH—The fall required would of course depend upon the shape of the channel and on the amount of water you proposed to bring into Bombay. It is impossible for me to give you anything like reliable information upon such a point as that. I suppose it is extremely similar to irrigation channels; they run for miles and miles at a slope of only three inches in the mile.

Colonel KENDALL—Yes, I know; but you would not get a slope of three inches in a mile in that country.

Captain TULLOCH—You do not require a natural slope. You could make an artificial slope partly by excavation, and partly by embankment. You can run a channel from Callian to Tannah. That is about eight or ten miles, but that is nothing at all for an irrigation channel. Take the delta of a country. For thirty miles straight on end it is as flat as a pancake, and there is no difficulty in making irrigation channels even there. It would be a similar work. I cannot see where the difficulty is. If you had the plans of a delta you would see what I mean.

Colonel KENDALL—The information I want is this—how would you cross that arm of the sea? At what level would you have the aqueduct made? You can start from any height you like from the hilly country beyond.

Captain TULLOCH—I do not say I would cross with an aqueduct at all. I do not see why it should not be crossed by a syphon. Of course in every work little difficulties will appear, and I would ask Mr. Aitken how he would carry his main. He would probably carry it right away under the creek: so would I.

Colonel KENDALL—You would begin at the existing level of the country, and cross the Tannah creek by a syphon?

Captain TULLOCH—Here I should most certainly. I do not think it would be possible to arrange the work so as to cross the Tannah creek by an aqueduct, judging from what Mr. Aitken says of the country here. Of course I do not know it.

Colonel KENDALL—That is what I want to know. You think it would be feasible to take the water over the creek by syphons?

Captain TULLOCH—I do not think it is a work which need distress any engineer. By running two or three pipes along the side of the railway, you would secure all the water the aqueduct brought down. How is the railway carried?

Mr. AITKEN—Twenty feet above high water mark.

Captain TULLOCH—I do not know the country, but it does not seem to me that it is a difficult work to carry out.

Colonel KENDALL—But would there be no difficulty in bringing water from that district into Bombay?

Captain TULLOCH—I do not think there would be any difficulty in carrying it out. It might cost a little more in crossing the creek. Constantly in works at home you cross a valley, and there you run your pipes down one valley, and up the side of the other.

Colonel KENDALL—Have you seen that?

Captain TULLOCH—I have seen one instance of it, on the Manchester Works, and the difference of pressure is only two, or three, or four feet.

Colonel KENDALL—Coming to pretty much the same level as the opposite side?

Captain TULLOCH—They arrange it so that they get precisely the quantity of water they want. If they want more water they must of course lower the level on the one side, or increase it on the other. By works carried out as the Croton aqueduct, and the Manchester and Glasgow Water Works have been, the Municipalities will not be put to expense again for years and years. Carrying out works in the way proposed here—that is, incurring an expense of half a million, then at another time incurring a similar expense when you want to increase your water supply by six gallons, and so on—you will go on until you have spent three or four millions, whereas for an outlay of one-third of that sum at first, you will get a much larger supply.

Colonel KENDALL—Then what do you recommend? That further examination should be made of Salsette and the country about before any action is taken?

Captain TULLOCH—I do not say that I am right, or that I am wrong; but I say that the subject is such an important one, that before the Municipality involve themselves in an expenditure of half a million of money, they should really have the subject investigated very much more fully. All these valleys should be thoroughly examined, instead of a single site being fixed upon. You should know that you are going about the work in the best way possible.

The CHAIRMAN—Have you been to the Vehar Water Works?

Captain TULLOCH—Yes.

The CHAIRMAN—Have you seen the dam there?

Captain TULLOCH—Yes.

The CHAIRMAN—The one which has been leaking?

Captain TULLOCH—No; I have not.

The CHAIRMAN—Judging from your experience, do you think it would be necessary to have another main pipe from Vehar to Bombay?

Captain TULLOCH—No; it is quite clear that it would be of no use. Mr. Aitken has shown in his report that the waste weir at Vehar has only overflowed three times since it was constructed. Under these circumstances, it would be no use at all. It would only be throwing away money by laying on another main. There I think Mr. Aitken is most emphatically right.

Mr. AITKEN (to the Chairman)—May I be allowed to put a few questions?

The CHAIRMAN—Oh, yes; certainly.

Mr. AITKEN—I presume from the recommendations you made just now that you are quite unacquainted with the nature of the country?

Captain TULLOCH—I have not been over the country, and I do not make my suggestions in the form of recommendations at all. My recommendations simply extend to this: that the question should be gone into and a report made on these points. I do not say that I am right or wrong; but in the absence of any information on the subject, I do not think it would be right to incur the expenditure of such a large sum of money.

Mr. AITKEN—Perhaps you are not aware that I have been for three years investigating that particular point, with a view to increasing the water supply. In the first place, you have to get the position for the dam.

Captain TULLOCH—Do I understand you to say that there is no place nearer than Shewla where you can get a dam? I venture to say that if I had a month I would give you a satisfactory answer on that point.

Mr. AITKEN—There is one place further off in the same valley, but I do not wish to speak with certainty as to that. But I would ask you whether you consider that a country which, from Callian to Bombay, is as level as Holland—so flat that it does not rise an inch either way—whether you can take the aqueduct from Callian to Bombay, with a fall of much less than six inches per mile?

Captain TULLOCH—No.

Mr. AITKEN—That would give you a rise at the other end of 20 feet for the 40 miles, so as to give you the proper fall over the flat country?

Captain TULLOCH—Yes.

Mr. AITKEN—At Callian?

Captain TULLOCH—Yes.

Mr. AITKEN—Do you think that could be done cheaper than the aqueduct I propose with a pipe?

Captain TULLOCH—You are now referring to the Shewla scheme?

Mr. AITKEN—Yes.

Captain TULLOCH—I say, most emphatically, yes. I have not said whether I would carry it above ground or below. I might take it below ground by excavating 20 feet, which is not a very serious matter at all. Suppose I was to start from Callian, as you say, with a slope of six inches in the mile. You say that slope is sufficient; that would bring me into Bombay with a cutting of 20 feet, which is nothing. I should cross the creek all right.

Mr. AITKEN—There is very high ground at Tannah.

Captain TULLOCH—Well, I could tunnel through that, but I understood you to say just now, that the ground was as flat as a pancake. Now you say there is a rise.

The CHAIRMAN—How would that work in the monsoon?

Captain TULLOCH—I am not departing from the usual practice.

Mr. AITKEN—The whole country is under water in the monsoon between Callian and Tannah.

Captain TULLOCH—I do not see what that matters. I would put puddle round the masonry. I do not see that it is a very serious thing; it is just doing again what they have done at Glasgow.

Mr. AITKEN—I understand you to say, that you propose to go below the level. If it should be below the ground, you would have all the country flooded above, and you would require to cover in the duct with an arch, so as to make it water-tight.

Captain TULLOCH—Yes.

Mr. AITKEN—Do you think that would be cheaper than the steel main proposed by me?

Captain TULLOCH—I think it would.

Mr. AITKEN—Well, all I can say is, I have tried both ways, and I find it would not.

Captain TULLOCH—That is not in your report.

Mr. AITKEN—I only give the results I arrived at.

Captain TULLOCH—You have given no results at all of what you arrived at on that subject.

Mr. AITKEN—Would you be kind enough to prepare a rough estimate?

Captain TULLOCH—It is very hard to ask me to prepare a rough estimate. If the Municipality would employ me, I should be very glad to do so. I do not see the slighest difficulty in carrying out the work. Here is the report of the Glasgow Water Works, which are 16 or 17 feet under ground, and you say I shall have to go 20 feet. It is only when I reach Bombay that the aqueduct be 20 feet under ground.

Mr. AITKEN—I suppose you know that the Glasgow main is carried along the side of the hill, and that at no place is it flooded?

Captain TULLOCH—That may be, but they have aqueduct in puddle at the top. Here is a section of the ground which holds water. I think I can meet you on that point. (Producing a plan.) There are open cuttings with puddling all around.

Mr AITKEN—There is no doubt about the way in which it should be done; the question is one of expense; and really I do not think it would take more than two or three hours for you to prepare a rough estimate.

Captain TULLOCH—I will if you give me the sections.

Mr. AITKEN—I can give you the section that I got from the Railway Company.

Captain TULLOCH—Of the whole 26 miles?

Mr. AITKEN—You can get it from the railway, you know.

Captain TULLOCH—If you will give me as much information as I want, I will do it.

Mr. AITKEN—How much would you put down for the cost of pumping engines in Bombay?

Captain TULLOCH—I can give you that information if you will give me a copy of my reply to you on the Drainage question.

Mr. AITKEN—It is 120-horse power. (Producing pamphlet.)

Captain TULLOCH—I will give you the cost of raising 10,000,000 gallons one foot high,—that is what you want, I suppose?

Mr. AITKEN—No; I want it for the 25 miles.

Captain TULLOCH—The whole cost?

Mr. AITKEN—There would be a very large annual expense for pumping.

Captain TULLOCH—You must capitalise that. To raise 12,000,000 gallons, 22 feet high, will require 30,000 Rupees annually.

Mr. AITKEN—That would be three lacs for pumping charges, because it is 12,000,000 gallons a year at five times that height.

Captain TULLOCH—Why five times the height? If I bring the water right into Bombay, it will be only 20 feet below mean sea level.

Mr. AITKEN—But we have a height of 80 feet, and besides you have a fall of 20 feet you have to pump from your depth to our height.

Captain TULLOCH—Take that and capitalise it; multiplying by 8, you get 36 lacs. I have to reach two millions yet Mr. Ormiston's estimate of the cost of your project.

Colonel KENDALL—If you could think a little more of this project which you have suggested, for bringing in the water through an open channel, it would be very interesting. It would be a very important consideration if it could be done.

Captain TULLOCH—I could not do it under some months.

Colonel KENDALL—You could not make a fresh project in less time in all probability, but I do not know why you cannot give us a rough estimate and put down on paper some of your views.

Captain TULLOCH—I should be only leading you astray without having proper information, and I have the greatest possible objection to giving an opinion of the details of such a large project without having sufficient information.

Colonel KENDALL—You know the levels are obtainable at the Railway Office.

Captain TULLOCH—That is only of the line of railway, but then you want to have the country roundabout on both sides of the railway, because you may be able to carry a great portion of water very easily on the slope of the hills. There is another plan; you may have an embankment, just as they do on the railway, and have a wrought-iron conduit at the top. But I should fancy that would be much more expensive, for then you would have the cost of the embankment and the cost of the iron as well.

Colonel KENDALL—You would make your information much more complete if you could give us some idea of the probable cost of an aqueduct. As it is, we do not really know whether what you suggest would be more economical than bringing in water by a main.

Captain TULLOCH—I don't say it would be practicable, but I think it is a subject that should be gone into. If I had a knowledge of the country I might give you an opinion, but it would be some time before I could do so now, or at all events an opinion worth having on the point. I could give you a rough idea the aqueduct will have, but that would be of no value at all; so much depends upon the kind of country you go through.

Colonel KENDALL—Do you think water would be spoiled by being brought in an open conduit?

Captain TULLOCH—If brought in an open conduit it should be filtered, but it need not be filtered with a closed conduit.

Dr. HUNTER—You would prefer a closed one?

Captain TULLOCH—Yes; a closed one just like that at the Glasgow Water Works.

Dr. HUNTER—You propose a reservoir with a larger extent of surface; would that be associated with shallowness or want of depth of water?

Captain TULLOCH—I said a dam 50 feet high, allowing five or six feet for evaporation, you would have 40 feet depth of water.

Dr. HUNTER—With the banks sloping?

Captain TULLOCH—The banks I fancy would be very favourable, indeed, for you see the valleys have high hills on both sides. If you formed a dam in any one of those valleys it would impound water very far up, I don't know how far. Then all the water in excess of the actual supply to Bombay could be utilised for irrigation, and of course that would pay. (To Mr. Aitken.) Do you mean to say that each of those rivers has a slope of 10 feet per mile?

Mr. AITKEN—Yes; and greater slopes.

Captain TULLOCH—I think you can hardly understand what I mean. Do you mean to say, Mr. Aitken, that each one of these rivers has a slope of 10 feet per mile?

Mr. AITKEN—That is the least of any one that I have levelled up.

The CHAIRMAN—I take it, Captain Tulloch, from the general tenor of your evidence, that you consider a further supply of water necessary for Bombay.

Captain TULLOCH—Oh, it is most important.

The CHAIRMAN—Is that apart from the question of drainage?

Captain TULLOCH—Oh, yes.

The CHAIRMAN—May I ask your reason for considering more water necessary for domestic purposes in Bombay?

Captain TULLOCH—The best reason I can give is what you see every morning—the struggle at the wells for water. It is really quite a sight at these drawing wells on a morning, and I am afraid to

say how many people at a time come for water. A hundred people are struggling and pushing each other. I think from the very nature of the case you may assume that the people don't get enough water, and if water is not placed conveniently for everybody, the greater portion of the inhabitants will not use enough of it.

The CHAIRMAN—If you had an increased water supply, how would you expect to distribute it, by house connections, dipping wells, or stand pipes ?

Captain TULLOCH—I should think Mr. Crawford or Mr. Aitken could give a better opinion on this subject than I can—it is such a practical question. I have not had charge of any water works.

Colonel KENDALL—Do you think natives would now use more water if they were not obliged to draw it from particular stand pipes ?

Captain TULLOCH—I am certain they would, and more still if it were placed more convenient for them.

Colonel KENDALL—You would increase the number of stand pipes then ?

Captain TULLOCH—I think it would be better for the poorer classes ; as to the wealthier classes I would give them water in their houses.

Colonel KENDALL—You said there was a great waste from all these stand pipes, and from wherever there was a cock ?

Captain TULLOCH—Yes; there is a very great waste, and that is characteristic of all water works.

Colonel KENDALL—Do you think there would be any great disadvantage, in a sanitary point of view, from the great quantity of water which would run to waste from the stand pipes, as it would do if the supply was increased in the native town ?

Captain TULLOCH—No; not at all.

Colonel KENDALL—You think there is not a sufficient quantity of water running to waste to make the ground appreciably wet; or is there not enough to make it damp ?

Captain TULLOCH—Wherever there is a stand pipe the water should flow from it directly to the drain, and if there is a tap running, the water would go into the drain. But I presume that care would be taken for erecting stand pipes or proper channels for the water to run down.

DR. J. LUMSDAINE, *Acting Health Officer of Bombay* :—

Examined by the CHAIRMAN :—

Q. What is your opinion as to the necessity for increasing the water supply of Bombay ?—A I think there ought to be an increased supply.

Q. Do you say that as the result of your experience as Health Officer ?—A. Yes, certainly.

Q. What supply per head ought there to be available for Bombay ?—A. I should say a minimum of 30 gallons.

By Colonel KENDALL—Do you mean to say that each person should draw 30 gallons, or that the supply provided by the reservoir should be that ?—A. That the reservoir should provide for that.

Q. And how much of that do you think should reach each individual ?—A. Well, not less than 5 gallons—but one man might perhaps get 10 gallons and another 70.

Q. But you think there should be 30 gallons for each person ?—A. Yes, that should be the provision.

By the CHAIRMAN—You mean, I suppose, not that each individual should get 30 gallons, but that the 30 gallons should be for domestic purposes, for watering roads, &c. ?—A. Yes ; to include everything.

By Colonel KENDALL—Have you any idea what has been found in towns in England to be the actual consumption a head per house ?—A. Actual consumption per *head* cannot be obtained. The *calculated* consumption per *house* is returned as 20 to 30 gallons.

Q. What return is that ?—A. Rankin's.

Q. Is that deduced from actual experiment, actual measurement ?—A. Yes. The average supply of 14 English towns of second rate magnitude was 24 gallons—largest supply 50 gallons, and smallest 14 gallons.

By the CHAIRMAN—That gives an average of about 20 gallons per head per day in non-manufacturing towns, and 30 gallons in manufacturing towns ?—A. Yes.

Q. And would you rate Bombay as a manufacturing town on account of the greater evaporation, climate and other reasons?—A. Yes; I would have the *maximum* supply for any large town in the tropics.

Q. Do you frequently get complaints, as Health Officer, regarding the insufficient supply of water?—A. No; because there is a great deal dra wn from private wells and tanks and other places—a great deal which ought not to be drawn.

By Dr. HUNTER—Are there any wells which, to your knowledge, are unwholesome?—A. Yes; when the cholera broke out in Cooleewaddy, Funiswaddy, Dr. Lyon was good enough to analyse samples of water for me taken from the well there, and the water was bad.

Q. Could you tell us the analysis?—A. Yes; it contained over 100 grains of solid matter per gallon, of which 26 grains were Chlorine, 6½ grains Sulphuric Acid, 1¼ grains Nitric Acid; 19·8 grains Lime, and 6·2 grains Magnesia. The water was very bad, and there were other wells just as bad.

Q. Does this unwholesome state result from cattle sheds being near?—A. No; but there are filthy drains from privies and other places. All these wells are used as washing places for washing clothes, cooking pots, bathing and washing cattle, and there must be percolation through the soil into the well.

Q. And there is a drain running near that well?—A. Yes; within a few feet.

Q. And that was the focus of cholera?—A. Yes.

Q. Can you mention any other well?—A. Yes; there is the well at the Alliance Mills.

Q. And over it the Municipality has no control?—A. None.

Q. And in order to close it what steps would you have to take?—A. The Municipal Act does not give any power over it at all.

Q. You would require a special Act to close it?—A. Yes.

By the CHAIRMAN—Are there many such wells scattered about in Bombay?—A. Yes; there are a great number. This table will show you the number of wells not supplied with Vehar water:—

Wards.	Supplied with Vehar Water.	Not supplied with Vehar Water.	Totals.
1.	7	668	675
2.	...	772	772
3.	...	893	893
4.	9	63	72
5.	...	111	111
6.	...	604	604
7.	...	179	179
8.	...	146	146
9.	6	480	486
10.	2	886	888
	24	4,802	4,826

Q. And the water in many of these wells is impure?—A. Yes. I have had occasion to suspect some, and have sent samples of the water to Dr. Lyon, who has analysed them and found that the water has not been what it ought; and judging from the way in which the generality of them are used, I have no doubt that most of them are impure.

Q. And in point of fact there are 4,826 private tanks and wells in Bombay over which the Health Department has no control?—A. Yes.

By Dr. HUNTER—And judging from what you said it is of great importance that they should be under your control?—A. Yes; it is a vital matter.

Q. As far as you are aware, is the Vehar water good?—A. Remarkably good.

Q. Have you any analysis?—A. Yes; Dr. Lyon has made an analysis, and even from the dipping wells, notwithstanding the filthy dipping vessels used, the water is remarkably pure.

Q. Better than the water generally used at home?—A. Yes; it is purer.

Q. And from the fact of the Vehar water being an intermittent supply but of good quality, and from the fact of these wells being used, do you consider that the water supply should be increased?—A. Most decidedly. I may mention that no analysis of tank water has been made, for this reason, I got a sample of water from the Bholeshwur tank and before it reached Grant College it was putrid.

By the CHAIRMAN—Was that before the tank was cleaned?—A. No; only the other day. And

you have only to go there any morning to see the state it is in; hundreds of people bathe and spit in it, and wash their clothes; and from year's end to year's end the water is unchanged.

Dr. HUNTER—I am aware of the condition of these tanks. In the tank at the Jamsetjee Hospital there is a large quantity of organic and inorganic matter, and I have obtained some fine specimens of animalculæ from it for microscopic purposes.

By the CHAIRMAN—In addition to the tanks mentioned here there are a large number of public tanks in Bombay?—A. They are all included there. These are all tanks not supplied with Vehar water. The quality of the water in all of them is about the same.

By DR. HUNTER—You said, in the beginning of your remarks, that 30 gallons a day should be the minimum. I think Mr. Rawlinson says 30 gallons per diem for manufacturing towns. Do you think that would be sufficient to meet the wants of Bombay?—A. Yes; I do. But if you could get an unlimited supply, so much the better.

Q. Do you think the general health of the inhabitants has improved within the last three or four years?—A. Yes. The Mortuary Returns show us that.

Q. Do you think that improvement in any great measure attributable to the Vehar water supply?—A. Yes; I think so.

Dr. HUNTER—I quite agree with you in thinking that there has been an improvement in the general health of the inhabitants of Bombay. I think we have less adynamic disease than we used to have, more especially in 1864. In 1864 the mortality was very high, owing to the rush of people to the island to meet the demand for labour; the supply of food and accommodation being insufficient to meet the sudden increase to the population.

By the CHAIRMAN—Have you any particular views of your own as to the best method of distributing the increased supply of water?—A. For the poor I would avoid house connections altogether. Their houses, as a rule, are indifferently built. The floors are of mud, the bathing places are badly made, and worse drained. In short, the houses are not fitted for house connections. I would have stand pipes and pavement all round them. I go about a good deal in the native town, and in most places where water is laid on there is a constant dripping, and the place is damp and mouldy—as bad as it can be.

Q. What is your opinion of dipping wells?—A. I would close them all, for, as they are, they are nuisances.

Q. Do you think a very large increase in the number of stand pipes in Bombay would have a tendency to injure the public health from their dripping?—A. From the stand pipes there need be no dripping.

Q. I thought you said that where you find stand pipes there you find dripping?—A. Many of the stand pipes are placed without regard to drainage, and there is a good deal of dripping; but you may have them in better positions.

Q. Do you agree with Captain Tulloch that with good sanitary arrangements no evils would result from an increased supply of water?—A. None whatever. It would rather be an advantage.

By Dr. HUNTER—Mr. Crawford, in his evidence the other day, stated that there would be no objection to using salt water for watering the streets, provided it were not more expensive than the water to be got from other sources. Do you consider that it would be objectionable to water the roads with salt water?—A. At home they have tried watering the roads with water much the same as sea water and have found it more economical. There, I fancy, they did not lift it.

Q. But, in a sanitary point of view, you see no objection to using salt water, provided it be as accessible as Vehar water?—A. Well, I think Vehar water would be preferable.

Q. What is your objection to salt water?—A. You would have a coating all over your streets which would make them more slippery. On mere sanitary grounds I am hardly prepared to say.

By the CHAIRMAN—Do you think the system of filtration to which Vehar water is subjected before its distribution is sufficient?—A. Well, judged by its purity as it is received, it is very satisfactory, and in private houses, I fancy, they all filter the water, but it is not *filtered* at Vehar.

Q. But as it is distributed to the public generally, do you think it is wholesome for them to drink as well as for other purposes?—A. Yes; I think the analysis shows that.

Q. You say you would not have house connections, but rather stand pipes for the poor. What quantity per head do you imagine natives would draw from the stand pipes for the consumption of each man?—A. I suppose from 4 to 6 gallons, probably 6 gallons.

By Colonel KENDALL—What amount does one of these large chatties hold?—A. I don't know, because you see people with all sizes of vessels.

Q. What is about the average quantity used by a family living in one of these native huts, men, women, and children? In England they count upon each house containing five people, but I should like to know what you think one of these small huts on the Flats would average?—From 5 to 7 persons—and the daily consumption from 5 to 10 gallons.

By the CHAIRMAN—I suppose it is impossible to arrive at an average of the houses in Bombay? —A. By the Census of 1864 there are 25,664 houses and out-houses, 3·970 families to a house, 7·694 persons to a family, 30·587 to a house, and 18·253 to a floor.

By Colonel KENDALL—In low-lying districts, where fever and other sicknesses are always rife, if you allow 10 gallons per head, and if there are five or six persons living in one of these small huts, what would they do with 50 or 60 gallons of water?—A. I don't suppose they would take very much more than they take now.

Q. How much do you think they take now?—A. From 6 to 8 gallons.

By the CHAIRMAN—A good deal of the water from the stand pipes would not be taken to the houses, but would be used in the washing of clothes, bathing, &c. The people don't bathe in their houses, and if you take away the tanks, where are they to bathe?—A. There ought to be places provided for them. Bathing as now practised is a great source of discomfort all through the town.

Q. You mean the habit of public bathing?—A. Yes; it makes the whole place so filthy. Wherever a native gets a stone to stand on there he washes himself.

Captain TULLOCH—I think it would be a good thing to do away with the tanks. If you had the water supply you could make the tanks with lots of taps.

The CHAIRMAN—Do you think there must be covered lavatories for them?—A. I think you might utilize many places you have now. Walkeshwur, Mahaluxumie, and other places might be utilized.

By Dr. HUNTER—Have you seen Canery and the other places where it is proposed to have schemes for water supply?—A. I have not.

The Commission then adjourned till Thursday, the 25th, at 2 o'clock.

THIRD DAY. THURSDAY. MARCH 25.

The following Commissioners were present—

ANDREW R. SCOBLE, Esquire, *Chairman.*
Colonel KENDALL, R.E. | Lieut.-Col. TREVOR, R.E. | Dr. HUNTER.
Dr. LYON, *Secretary.*

The Commission resumed at 2 o'clock on Thursday, in the Durbar Room, Town Hall.

CAPTAIN HANCOCK, R.E. :—

The CHAIRMAN—What was your particular appointment in connection with the Vehar Water Works?

Captain HANCOCK—I was Consulting Engineer from March to September, 1865.

The CHAIRMAN—You are well acquainted with the Vehar Water Works, I suppose?

Captain HANCOCK—Not very well, but I have read the reports concerning them, and have been there occasionally. I have not made any very careful study of the water works at Vehar or elsewhere. I reported in May 1865 on the state of the lake at that time, and my report gives certain particulars concerning it, which I obtained chiefly from the contours of the lake which have been prepared by Colonel DeLisle. It was shown in that report that the lake contained, when about quite full, about 10,800 million gallons; that the then present consumption was about 400 million gallons per month, or 4,800 million gallons a year; that the average rain-fall added about 5,200 million gallons to the lake; but that it would not be safe to assume this as a fixed rule, the increase to the volume of the lake caused by a rain-fall of a certain number of inches varying much according to the manner in which the rain falls. A sudden fall will have more effect in filling the lake than the same quantity of rain spread over several months. During 1864-65, the rain-fall being much below the average, the supply added to the lake was 3,600 million gallons only, and the greatest depth of the lake during that year was 55 feet. In 1864-65, up to 15th June, taking the rate at which the expenditure had gone on, the expenditure, had no rain fallen before that date, would have been 1,200 million gallons in excess of the supply in the same year. The water in the lake would then have stood at a depth of 44·25 feet. It so happened, however, that the rain set in earlier. I then entered in my report into the various depths of water in the lake. I pointed out that during a succession of unfavourable years, such as 1855 to 1858, the average supply of water would not balance the present consumption. Supposing the four years 1865-68 to be as unfavourable as 1855-58, the lake would stand at 35 feet only, and would contain only 3,200 million gallons. This of course was an extreme case, but not an impossible one. Were the consumption increased by only a fourth, the lake would be dry long before the fourth year had expired. The conclusions that I drew from this were as follow :—That the supply of water to the lake is not much more than sufficient to meet the present drain upon it in average years; that to admit of any increase it would be necessary to provide for the lake being filled every year, and kept full during the monsoon months, and even this would barely allow of the doubling of the present consumption. I recommended that early steps should be taken to render the lake capable of affording a larger supply than the present. That as a commencement it would be advisable to cut a channel from the lake along the western face of the high hills of Salsette till it met the next large stream; that this channel should be provided with sluices, and would thus serve to divert into the lake some of the water now carried to the marsh to the westward. That this should be completed before any attempt was made to lay on a second

main. At a future date it might be necessary to make a second reservoir. This part of the report was written with reference to a proposal made by the engineer then in charge of the Vehar works to lay a second main immediately with the view of abolishing the inconvenient and intermittent supply of water in the town. And I may add that I had in contemplation, not merely the increase of the collecting area of the lake by these drains, but also the establishment of small reserve reservoirs in convenient places round the lake where they might be cheaply constructed, which would serve to increase the storage capacity of Vehar Lake, and also to keep the head higher on the average during the year, and thus in some way remove the inconvenience arising from the want of pressure, which is very much felt, on the higher levels of the town, during the hot weather. At this very time the pressure is so small that on Malabar Hill at night the water frequently does not come into the bungalows. I have experienced that to be the case in my own bungalow, and I have sometimes been three or four days altogether without water.

The CHAIRMAN—With reference to the supply of Vehar water, do you consider the dams in sufficiently solid and strong condition to bear any additional pressure?

Captain HANCOCK—No; there was nothing in this proposal which would have increased the pressure beyond what the pipes are now subjected to during the monsoon. The lake cannot be more than full. At the same time, from the reports I have read since my report was written, I should say it is desirable that these dams should be very carefully overhauled and perhaps repaired, and I should think there is nothing to prevent the necessary repairs being carried out to make the dams sufficiently strong to be depended on. If they are not sufficiently strong just now, it is essential that they should be made so.

Colonel TREVOR—Have you any reason to suppose that they are weaker now?

Captain HANCOCK—No; but according to the reports we have seen since they are. The only dam, of which we had any suspicion when I was in charge, was No. 3, and I visited that dam in May 1865. The water was then low, and the leakage inconsiderable; and afterwards I consulted with Colonel DeLisle about the leakage, which increased very much when the lake rose in the succeeding monsoon, and he then thought seriously of the matter, as you will see from the proceedings of the Committee which was held in July 1865. Colonel DeLisle then brought to notice the considerable, and in his opinion very dangerous, leak, and the Committee proposed certain repairs. These repairs were afterwards undertaken by Mr. Russel Aitken, who carried them out in a different was from that recommended by the Committee, for when he went to the dam he found it in a worse state than even Colonel DeLisle thought.

Colonel TREVOR—Do you know any dams that are completely water-tight?

Captain HANCOCK—No; there is a certain amount of leakage in all dams.

Colonel TREVOR—And that does not show that they are insecure?

Captain HANCOCK—No; that depends on the ground and the position of the lake.

The CHAIRMAN—Is the fact that the discharge pipe passes through the dam an additional source of insecurity?

Captain HANCOCK—I suppose it is, but there is no leak of any moment in the dam through which the pipe passes. There has always been a small leak there, but we thought the leak was between the pipe and the masonry.

The CHAIRMAN—Supposing that a further supply of water to Bombay be necessary, do you think it would be better to have an independent source of supply instead of trusting to a further supply from Vehar?

Captain HANCOCK—Certainly, I think it would be better, provided you can afford it. These recommendations, I may point out, were supposed to be measures for increasing the capabilities of the present Vehar Lake at a small additional cost. There were at that time no detailed surveys to show the possibility of the scheme or its cost. I was in consultation with Colonel DeLisle about this, and it was his view that the valleys about Vehar would probably afford sites for small reserve reservoirs where water might be stored and let into the lake as the water in the main lake fell.

Dr. HUNTER—Do you know if there are such sites?

Captain HANCOCK—I do not know of my own knowledge.

Colonel TREVOR—Do you consider the water supply of Bombay insufficient?

Captain HANCOCK—It would be insufficient were it not for the supply from tanks and wells.

Colonel TREVOR—Don't you think twelve gallons a head per day enough for Bombay?

Captain HANCOCK—Yes; for drinking purposes and for household purposes; but for watering the roads, for irrigating gardens, washing, and things of that kind, I should say it is not enough.

Colonel TREVOR—Would not salt water do for watering the roads ?

Captain HANCOCK—Better, I think.

Colonel TREVOR—And would not it do for washing ?

Captain HANCOCK—Tank water might do for washing.

The CHAIRMAN—Is not the expense of watering the roads with salt water much greater than by doing it with Vehar water ?

Captain HANCOCK—There would be an extra expense in the first instance, because you would have to get some means of raising water. When that is done, I don't see why one should be more expensive than the other. You might have convenient points where the water should be pumped up.

Dr. HUNTER—You see no objection to watering the roads with salt water ?

Captain HANCOCK—I have heard that it injures carriages, but I doubt that very much. It improves the roads. Salt may possibly do some harm to the iron work of carriages, but I do not think so.

Dr. HUNTER—The only objection the Municipal Commissioner saw was the increased expense.

Captain HANCOCK—I have made no estimate of what the expense would be, but it appears to me that it would not be very great.

The CHAIRMAN—I suppose the cost of the pumping engines for supplying the salt water would be considerable ?

Captain HANCOCK—I have made no estimate, but I should think not very considerable.

The CHAIRMAN—Would you have pumping engines at various points ?

Captain HANCOCK—These are details which of course would have to be considered. I should think the plan would be to raise the water at more than one point by ordinary pumps ; they need not be worked by steam engines.

Dr. HUNTER—Do you think the lake would be sufficient to supply water for sewage purposes ?

Captain HANCOCK—No ; I do not.

Colonel KENDALL—Were you on the committee for increasing the supply ?

Captain HANCOCK—Yes.

Colonel KENDALL—And you stated just now, I think, that Mr. Russel Aitken's reports showed that the lake has only been full twice.

Captain HANCOCK—I think it overflowed once before this committee assembled and once since.

Colonel KENDALL—Do you think the committee was of opinion that the gathering ground at Vehar could be increased ?

Captain HANCOCK—It was thought so.

Colonel KENDALL—And do you think there is anything to prevent the dams being heightened ? Would it be safe to do so ?

Captain HANCOCK—I should say it would be unsafe, unless at the same time they are very much widened. However, it is feasible ; but, as I said before, I have made no special survey. I do not think the committee contemplated the raising of the dams, their idea was to have supplementary reservoirs on a small scale to supplement the drainage into the lake, but they said nothing about raising the dams. I have seen that suggested in other reports. I have seen it suggested by Mr. King, Resident Engineer.

Colonel KENDALL—But you see no objection in an engineering point of view ?

Captain HANCOCK—To a certain extent the dams might be raised—a few feet perhaps—provided they were strengthened also. There is of course this, that if you increase the height of water you increase the pressure on the main also, and I don't know how the main will stand it.

Colonel TREVOR—You could meet that by keeping the ends of the pipe open.

The CHAIRMAN—Do you think there would be any advantage in having a second main from Vehar ?

Captain HANCOCK—Very little. It certainly would increase your consumption very much, and besides I don't think we have the money.

The CHAIRMAN—Have you gone at all into Mr. Aitken's scheme for the extension of the water supply ?

Captain HANCOCK—I have read them, but have not gone into the details.

The CHAIRMAN—Do you know the country about Canery or Shewla ?

Captain HANCOCK—No.

The CHAIRMAN—Do you think, from an engineering point of view, that there would be no greater inherent danger in a properly constructed dam, 136 feet high, than in a properly constructed dam of a lower height ?

Captain HANCOCK—I think it would be quite possible to construct a safe dam 136 feet high. That is certainly very high, but I don't think *per se* it is unsafe.

Colonel TREVOR—You don't know the defects in the construction of the Vehar works ?

Captain HANCOCK—No. I never was in Bombay till after they were constructed. Of course I think the work you mention is a formidable one, and if two schemes were equal in other respects I should prefer the one with the lower dam.

The CHAIRMAN—You have not gone into the schemes in the way of making any calculation to test Mr. Aitken's figures ?

Captain HANCOCK—No; I have not had time.

The CHAIRMAN—With regard to the Shewla scheme, are you able to form any opinion as to the proposed steel main ?

Captain HANCOCK—I have no opinion to offer on that point, but steel is coming into more general use. They are getting steel boilers for engines and locomotives now, but it is a material which is comparatively new for the purpose proposed.

The CHAIRMAN—Are you aware of its ever having been used as a main for carrying water ?

Captain HANCOCK—No; I am not aware of any such instance.

The CHAIRMAN—Do you know anything of the country between Shewla and Callian ?

Captain HANCOCK—Very little.

The CHAIRMAN—Do you think it would be practicable to bring water down from that part of the Ghauts by an open aqueduct ?

Captain HANCOCK—I should think it would be practicable.

The CHAIRMAN—At less expense than by a steel main ?

Captain HANCOCK—Well, that is a question of estimate again into which I have not had time to enter; but, as far as I know, there is nothing to prevent a channel being made from the site of the Shewla reservoir.

Colonel TREVOR—Would it be possible to exceed one and a half lakhs on that ?

Captain HANCOCK—As I have said I have not made any estimate. I do not know what works might be necessary. You might have some very expensive aqueduct.

The CHAIRMAN—Do you think there would be any difficulty in bringing water from Callian to Bombay through the low-lying ground ?

Captain HANCOCK—There would be some expensive aqueduct probably.

The CHAIRMAN—Do you know the country between Callian and Bombay ?

Captain HANCOCK—I have been along the Railway very often. I am sure channels must have been made through quite as difficult places as this.

The CHAIRMAN—But from the nature of the ground would it be an expensive work ?

Captain HANCOCK—I should say it would be expensive.

The CHAIRMAN—With regard to your proposal as to reserve reservoirs being made in the country round about Vehar Lake, could these additional reservoirs be constructed without interfering with the present drainage area of Vehar Lake ?

Captain HANCOCK—Yes, I think so ; there was one particular stream which was mentioned in this report. The idea was that some of the water which now finds its way to the valleys to the west does not find its way to the lake at all. (Captain Hancock then pointed out on the plan the valleys referred to.)

The CHAIRMAN—Would the construction of these additional storage reservoirs involve any large and expensive works ?

Captain HANCOCK—I never went into that subject at the time. We suggested that the ground should be surveyed in order to find out what extra supply would be afforded and to see whether it would be worth while to undertake them.

The CHAIRMAN—The Toolsee scheme is cheap, 16½ lakhs.

Captain HANCOCK—Yes ; but that includes a second main, and I do not see that the carrying out of that project necessitates a second main. The cost of strengthening the dam at Vehar would be necessary in any case, whether you adopt the Toolsee scheme or not. As I said before you can't bring more pressure on the dam than the maximum pressure when the water is running over the waste weir.

The CHAIRMAN—Do you know whether it was ever proposed to bring water from Vehar by an open canal ?

Captain HANCOCK—I think the project was discussed when the scheme was first taken up.

The CHAIRMAN—And abandoned?

Captain HANCOCK—Yes; but I am not up in the previous correspondence. I have a mere recollection of reading that at one time it was proposed to have a canal.

DR. LUMSDAINE :—

The CHAIRMAN—I understand you wish to hand in a further memorandum in continuation of your former evidence?

Dr. LUMSDAINE said he wished to do so, and handed in the following Memorandum on extending the water supply for Bombay :—

The points that have a direct bearing upon the question in its sanitary aspect are the following :—

1. Quantity.
2. Quantity from impounding to distribution.
3. Mode of delivery with reference to habits of recipients.

In dealing with quantity it must not be forgotten that whatever the amount it must be in proportion to the provision for ultimate removal, or rather there must be drainage equal to the removal of the maximum that any circumstances might demand. It will be well, too, if we deal with the case as though there were no other source of supply than that now received from Vehar, for although there are tanks, these cannot, under existing arrangements, be admitted into any calculation, as they are nothing more than huge cesspools in which persons and clothes, wash, and are washed, in a water that is never changed. The wells, too, are little better. Few, if any, have ever been cleaned. The majority are utterly neglected as to condition—and many are beyond a doubt impure by permeation. The quantity then is that required for all purposes, for human and animal life in a tropical country where the masses are engaged in manual labour where draught is heavy, and where religion enjoins that ineffective and useless animals are still to be supported.

It is required for drinking, for cooking, for bathing, for house purposes, for horses and carriages, for draught and milch cattle, for ornament, for use in gardens, for accidents by fire, and last, but not least, for flushing.

It is of little use to say the well and tank water can be utilised. It can, no doubt; but every where, at those places where horses and carriages are in greatest numbers, there is the pipe, and no labouring man will draw the water when he can get it by simply turning a tap.

Taking into account all these matters I would fix the *minimum* at 30 gallons per head per diem.

Quality—When rain is the source we may safely assume that the supply will be of good quality, and, with ordinary precaution, the suspended impurities may be reduced to a minimum. At the place of impounding there are two precautionary measures that must be adopted. One is filtration, the other is that, as long as the supply is equal to escape by the waste weir, so long should there be a created scour at the ground surface of the reservoir.

Mode of delivery—Custom and habit are elements under this head, and in facing them we are fairly puzzled. We come across men so holy that the profaned pipe is rejected as unclean; there are others less holy—I speak under correction—who not only don't object to it, but who supply themselves surreptitiously from urinals and other sources. There are some who are perpetually washing, there are others who never do so, and again there are those who by preference take a water well-nigh putrid. For one and all there is required both precept and example; and to the great unwashed there should be offered the means of further developing the desire to be clean.

As we deal with a people who by custom are "drawers of water," I would discourage house connexions for the poor, and would replace them by well-drained stand pipes in sufficient numbers with a better delivery than the present strictured stream. I would close those abominations, the dipping wells; and for the general condition of private wells and tanks I would hold responsible the owners, accredited owners, and trustees. Wherever practicable I would reclaim their arrears and utilise them.

It may be accepted as a certainty that if Baths and Lavatories were erected they would be largely used—and in place of the filthy sights and more filthy practices that are now so horribly obtrusive, we should have institutions that might hereafter be self-supporting.

(Signed) JOHN LUMSDAINE, Health Officer.

Bombay, March 25th, 1869.

Examined by the CHAIRMAN—As you are here, Dr. Lumsdaine, allow me to ask, in reference to your evidence the other day as to your not having the power to close wells which contain water dangerous to health, whether you have found that power is not given by the Municipal Act?—A. I think not.

Q. I see that Section 175 of the Act gives power to the Commissioner to fill up unwholesome tanks on private premises if required, or to draw off and remove stagnant water?—A. It says that notice is to be served, and that if the owner neglects to comply with that notice the Commissioner himself may enter on the ground and do the work and recover the cost. By that interference the

Municipality would incur the current expense of the work and then recover; and we are not in a position to do so. There was the other day the case of the Bholeshwur Tank, where the Municipality entered upon the work and did perhaps rather more than was needed, and had to pay the cost.

Q. Has any distinction been taken between tanks and wells ?—A. I do not think that question has ever cropped up in Court. The Bholeshwur Tank case was taken into Court because the owners disputed the right to recover the cost of cleaning and repairing the bottom.

Q. Then the difficulty of dealing with these unwholesome wells is a question of expense rather than anything else ?—A. There has been no legal distinction of what is a tank and what is a well. You may take a case into Court, and one Magistrate may take one view of it, and another, another.

Q. I see also section 174 of the Act empowers the Commissioner to set aside bathing places ?—A. Yes.

Q. Have any places been set aside for bathing ?—A. No. The Municipality has no means to construct them and set them aside; and then there is not a sufficient water supply.

Dr. HUNTER—The intention of the Act evidently was that you should have the power of getting rid of those nuisances which are dangerous to the public health ?

Dr. LUMSDAINE—Section 144 is the only section by which we can work practically. It is very elastic.

CAPTAIN TULLOCH :—

Captain TULLOCH—At the last meeting Colonel Kendall asked me for particulars regarding the channel which I proposed. The question was put to me—Supposing we have got water to Callian how is it to be brought into Bombay ? Is that a correct expression of the question ?

Colonel KENDALL—No. The question was this,—If a large reservoir had been found at a considerable height above Callian, which you considered was quite feasible, then would there be no difficulty in bringing in the water to Bombay in an open aqueduct and distributing it there by means of a stationary pumping engine ?

Captain TULLOCH—As I understood it, the difficulties began from Callian, because we have a good slope above Callian. Mr. Aitken himself, if you remember, stated that the least fall which any of these rivers had above Callian was ten feet per mile. Whatever the slope is, it is no doubt ample for any channel down to Callian. The question is, having got the water to Callian, how is it to be brought to Bombay ?

Colonel KENDALL—Yes.

Captain TULLOCH—I was not prepared to answer that at the last meeting, because I had not gone into the subject very minutely. But a question of that kind should of course be asked with reference to the form of the channel and the soil it is to pass through, and various other considerations.

Colonel KENDALL—And also the level ?

Captain TULLOCH—Yes, and the level of the ground, and certain other things. The first thing to ascertain is, would this give you as much water as Mr. Aitken's 4½ foot pipe from Shewla ? Now I find that a 10 foot square channel would give us 105 million gallons per day, with a fall of 1 foot per mile. That is four times as much as Mr. Aitken's 4½ foot main would give.

Colonel TREVOR—What formula do you use for that ?

Captain TULLOCH—$v=55\sqrt{2hf}$., which is a modification of Eytelwein's.

It does not differ from 3 to 5 per cent. from Du Buat's. With a ½ foot fall the same channel would give 74 million gallons daily, or more than two and a half times the quantity of water which the Shewla main would bring down. A channel 8 feet square, with a semi-circular arch thrown over it, would give us 65 million gallons per day. That is about two and a half times as much as Mr. Aitken's main would bring down, and that would be equivalent to about 75 gallons per day per head of the present population. That will give you an idea of the size of the channel required to bring in a sufficient quantity of water—a quantity very much in excess of the present wants of Bombay. Of course if you wish merely to bring down 30 gallons per day, the size of the channel would be very much smaller and the cost materially reduced. But I do not think that would be a wise way to proceed with regard to the water supply of Bombay. The plan would be to go in for a large main, which is what all the great towns have gone in for, such as Glasgow and New York, the latter city being the most notable example. They don't draw all the water the channels can convey, but when they want a greater

supply, they simply let in more water. And thus for the next fifty years I suppose they will not have to make any alterations on the Glasgow Water Works. I do not know the statistics of the Water Works at New York, but I should fancy the same state of things prevails there. The other question asked was, what line the aqueduct would take from Callian ?

Captain TULLOCH then pointed out on the map the line he would propose, and afterwards continued—We may have to put down a cast iron main, but that would only be for two miles, but on crossing the river we are again on a ridge of hills which run down to Coorla, so that we shall have got over about twenty-six miles of the difficulty at once.

The CHAIRMAN—Then from Titwalla to about Coorla, except where you cross the Tanna creek, you again have high land, along which you can carry your canal.

Captain TULLOCH—Yes, we can select our slope exactly. I daresay we shall be able to bring the aqueduct into Bombay at a good level. I cannot give you any information about the cost of the work, but Captain Ducat has been Executive Engineer of that very district, and therefore knows the capabilities of it, and can give you much more satisfactory information on that point than I can. I have now given you the sizes of the channel, which will deliver more than two and a half times as much as Mr. Aitken's main from Shewla, and the line by which I would bring it to Bombay.

Colonel KENDALL—And is the ground likely to be favourable ?

Captain TULLOCH—Most favourable. However, Captain Ducat knows a great deal more about it than I do, because I have been over only a portion of it, and have only seen the rest of the ground from the railway.

Colonel KENDALL—Thank you. These remarks of yours have made your evidence much more complete than it was.

Captain TULLOCH—In addition to the channels, there will be the cost of pumping the water, and I am quite prepared to go into that.

CAPTAIN DUCAT :—

By the CHAIRMAN—Have you gone into the matter of the reservoir at Shewla, and the possibility of bringing water into Bombay from there ?—A. Knowing the country, I thought I might tell the Commission what I knew of it. I was Executive Engineer there for four years, and I know the country in a general way, and I believe that, as Captain Tulloch has stated, there would be no difficulty in making a convenient and cheap aqueduct the whole way, with the exception of crossing Tanna creek. Half a mile on this side of that creek you can get on to high ground and choose your level again. There is no difficulty the whole way from about here (pointing to the situation on the plan). I had to survey a road from Titwalla to Moorbar. I had to cross that river on two occasions. I do not recollect all the details now, but I recollect it in a general sort of way. You can get ground there giving an ample flow into Bombay.

By Colonel KENDALL—Perhaps you would say whether it is your opinion that a reservoir might be formed in some valley nearer than Shewla ?—A. Yes; I think it could.

By the CHAIRMAN—And that this river should be dammed below Moorbar ?—A. No; Carloo River. (Captain Ducat then fully explained his meaning to the Commissioners by pointing out the different places on the plan.) Not only, said he, would you have a less distance to bring the water, but you would have a smaller area to dam, for the further down he river you get, you get less incline and consequently a larger quantity of water with the same amount of work.

By Colonel TREVOR—Does not it follow that the greater amount of water you bring down the greater amount of silt you have ?—A. No ; I do not think so.

Q. Is it not one of the principles of tank building that the quantity of water entering the tank should be as nearly as possible the quantity required to fill it, and that as little as possible should go over the waste weir ?—A. That would be the case with a small tank, which would be apt to get silted up.

Q. But it would also hold good in this case ? (No answer.)

Q. Have you any idea of what would be the cost of the construction of a channel through this country ?—A. Yes; I took it down this morning, though I have not got it in clean form to put before the Commission. A channel eight feet wide, with a circular arch over the top, would be, under the most unfavourable circumstances you would be likely to have, about Rs. 1,30,000 per mile. If it was not necessary to cover this, which I believe it would not be in a great many places, and supposing the

soil to be good, as it is most of it (hard dry moorum), it probably might be done for under Rs. 20,000 per mile. That is the most expensive section you would be likely to meet.

By Colonel TREVOR—Do you find the materials for building such channel in the country itself?—A. Most of the materials are there. There is stone all along the country. You would have to import lime, but your water carriage is very good.

By the CHAIRMAN—Do you think bringing water down by means of such a covered channel as this would be preferable to bringing it down by a metal pipe?—A. Yes. And then this work leaves nothing to risk, such as there would be by using a three-eighths of an inch pipe. Many pipes are apt to be honeycombed, which might not be ascertained till afterwards. And the cost of the carriage of pipes over this country would be very great; in fact, the only way to carry them would be to build the road to carry them on. You could only carry anything heavy by coolies, and coolies could not carry a four and a half foot main.

Mr. AITKEN—Government is now making a new road to Moorbar.

Captain DUCAT—Yes; and they were going to do so for many years before I went to the Concan.

Mr. AITKEN—They have begun it now.

Captain DUCAT—They may, but it was talked of before I went there; and it is seven years since then.

By the CHAIRMAN—Would you be in favour of a covered channel?—A. I think not. I believe running water is quite as safe or even more safe if it is exposed to the air. I think running water is better from being exposed to the air. I speak subject to correction by the medical officers, but I think it is better from being aërated by being exposed to air in an open channel.

Q. If it were an uncovered channel, the cost would be much less?—A. Yes; only about Rs. 20,000 or Rs. 25,000 per mile under ordinary circumstances.

Q. Then an eight-foot channel would carry 75 gallons of water per head for the present population of Bombay, which is a great deal more than the most ardent sanitarian would desire. Would there be any means of disposing of the surplus water along the road?—A. I know that in Callian and Bhewndy there are very many persons who would gladly pay highly for water, and the same holds good at Tanna, where they have been attempting to lay down a main from a spring; but even if that has been done, it must give a very doubtful supply. I do not know whether it has been done, but if it has, it will not give anything like the supply they require.

Q. Then this would not only supply Bombay, but the intermediate towns on the road?—A. Yes; and also the railway. They would be glad of water at Titwalla.

Q. Do you think there would be any demand for water along the line for irrigation purposes?—A. There would no doubt at certain places, but not very much.

Q. What is the character of the land for the most part along which this proposed line of canal would pass? What is the nature of the crops?—A. Bhewndy is a great salt country, but there is very little rice grown there. In some other parts they grow corn, although I am not quite sure of the nature of the corn. Then there is rice grown between Callian and Bhewndy, and there would be no difficulty in disposing of any quantity of surplus water for irrigation purposes, if it was cheap enough. At Tanna, I fancy, they would use it for irrigation very gladly if they could get it. There they irrigate their gardens from wells. Tanna, Bhewndy, and Callian are all large towns, and would take a large supply. At Bhewndy there is an immense number of cattle for carrying on the salt trade, and the inhabitants of those towns would probably take a very large quantity of water.

Q. You would not be able to do much for Callian if you followed the line of country Captain Tulloch has shown?—A. Not very much, but it would be worth while to lay down a syphon for them: a nine inch pipe would probably give them all they wanted. Bhewndy is the chief town.

Q. I think you said that you did not think any supply of water could be got from the heights above Bassein?—A. I think not; at all events not a large supply.

Q. And even if you could, it would be an expensive work, on account of the cost of the land?—A. In that part it would be. At least I know of no place there where it could be got cheaply.

Q. Do you know the land about Canery?—A. I do not know much about that part of Salsette. I have not done work of any sort there.

Q. You do not know the place where it is proposed to build this 136 foot dam?—A. No; I know the valley, but I do not know the site of the proposed dam.

DR. EDULJEE NUSSERWANJEE :—

Examined by the CHAIRMAN—I believe you are a graduate of the Grant Medical College, and a medical practitioner with a considerable practice in the native town ?—A. Yes.

Q. Will you give us your experience as to the sufficiency of the present water supply of Bombay ? —A. As far as I am aware, there is a general complaint about the insufficiency of the water supply. Every householder who is supplied with Vehar water says the quantity is insufficient to meet the usual wants.

Q. Is the complaint as to the quantity of water supplied or as to the want of a continuous supply of water ?—A. It is more I believe as to the want of a continuous supply. If they were to store up the water at the time they can get it, the supply would be enough, but they cannot get the water when they desire it.

Q. They cannot get it at all times of the day ?—A. No; for several hours they do not get a drop from the pipes. I have often found that for several hours I could not get a drop from my pipe.

By Colonel TREVOR—But at other times you can get as much as you like ?—A. Yes; more particularly towards 5 o'clock.

Q. Then all that is required is to have a cask to store the water in ?—A. Yes.

By the CHAIRMAN—From your experience, what would you say should be the daily supply of water to each individual in Bombay ?—A. I think two large potfuls, such pots as our people generally use. We call them mutkees. I suppose each mutkee contains five to seven gallons, and two of such vessels would be sufficient for each individual.

By Dr. HUNTER—Is that for one individual, or for every house simply ?—A. For one individual.

Q. Then you want from 10 to 15 gallons per head ?—A. Yes.

By the CHAIRMAN—Are you speaking of Parsees only, or natives generally ?—A. I suppose there is very little difference between Parsees and Hindoos; a Hindoo requires more than a Parsee, I should say, for they have certain customs and observances for which they require a greater supply of water.

By Colonel TREVOR—You are counting the grown-up people only ?—A. Yes.

Q. I suppose children use less ?—A. Well, I suppose five gallons for a child would be quite enough.

By Dr. HUNTER—It is only for personal use you are speaking, not for cattle and other purposes ? —A. Yes; only for personal use. The practice of daily bathing is almost universal, and each individual requires at least one mutkee full of water, and that would be more than seven gallons.

By the CHAIRMAN—That is for each man, woman, and chid ?—A. Yes; each man and woman would require that, and a child, one half or three quarters as much.

By Colonel TREVOR—There are many houses where the people have to bring the water from the wells on their heads ?—A. Not generally in the case of Parsee houses inside the Fort.

Q. But outside the Fort ?—A. Yes; in small dwellings. In the case of houses where there are no wells, the people bring the water from the wells situated in the streets.

Q. Do you know how many gallons they bring in for a family ?—A. A small family of three or four individuals would require six mutkees a day.

Q. Do they bring the water upon their heads ?—A. Yes.

By the CHAIRMAN—Have you tested any of the water in these private wells ?—A. No.

Q. But apart from any chemical test, have you been able to form any opinion as to the quality of the water in the wells ?—A. I have formed no opinion as to any particular wells, but I have sometimes seen some particular wells, which, from the appearance of the water, I think it would be hazardous to use it for drinking purposes.

Q. Most of these private wells are open ?—A. Yes; generally open to light and air.

By Dr. HUNTER—Have you been to any of those particular places in Bombay which have been visited by cholera ?—A. I have seen the disease here and there. It is not confined to any particular locality.

Q. Have you not observed any connection between cholera and the water supply ?—A. No; such connection has been traced to the water the people have been drinking, but I should say the origin of the disease is to be attributed to the filthy condition of the drains.

Q. Which do you prefer, the Vehar water, or that which is in the private wells or tanks?—A. I should say there are very few houses in Bombay which are not supplied with Vehar water in these days.

By the CHAIRMAN—Of which part of Bombay are you speaking?—A. The Fort.

Q. Have you had any experience with reference to places outside the Fort where cholera has been rife?—A. No.

By Dr. HUNTER—You do not know if the disease can be traced to the water in private wells, and so forth?—A. No.

By the CHAIRMAN—Do you consider the Vehar water superior to the well water?—A. I think so.

Q. Have you a well in your own house?—A. Yes; it is supplied with Vehar water.

Q. And you use it for all purposes?—A. Yes; I recollect a case of cholera which once occurred up Malabar Hill, which originated in the Dhurrumsala.

By Dr. HUNTER—Not during the last outbreak of cholera?—A. No.

Q. Do you know of any wells inside of Parsee houses in the Fort, in which the water smells, or is offensive?—A. This year I observed the water in several wells inside the houses in one street was contaminated with offensive matter, and that seems to have resulted from some water which had found its way from the refuse of the fire which broke out in Borah Bazaar Street, where several liquor casks were burnt. The water that was pumped over the burning materials permeated into the wells of all the houses in that street, and for several days the water in the wells was very offensive and dirty. Several of these wells were, to my knowledge, emptied by pumps and cleaned, but I do not recollect any outbreak of cholera.

Q. Do you know of any wells inside houses, besides these, where the water was offensive?—A. No.

By the CHAIRMAN—It frequently happens that the wells are built inside the houses themselves?—A. Yes.

Q. Do you consider that a wholesome arrangement?—A. I do not consider it is a very wholesome arrangement, for generally the distance between the sewer of the houses and the well is very little.

By the CHAIRMAN—The sewage matter drains into the wells?—A. It is very possible it might.

Q. I suppose all these wells in the Fort are liable to have the sewage water drained into them on account of cracks in the chunam, and so on?—A. Yes.

Q. The wells are very old, are they not?—A. Yes; some of them are as old as the Deluge.

By Dr. HUNTER—Almost all the houses in the Fort have their privy on the ground floor, have they not?—A. Yes.

Q. And the privies are all close to the wells?—A. In some cases the distance is as little as six or seven feet.

Q. And from your knowledge of the habits of the natives, their carelessness on many points of this kind, you think the sewage might run through and into the well?—A. Yes; that is very likely.

Q. Do you consider it would be wholesome to have these wells closed?—A. I think so.

MR. RUSSEL AITKEN:—

MR. RUSSEL AITKEN was then examined regarding the leaks at the Vehar Lake. He said—In the appendix to my report will be found the whole of the details respecting the Vehar Lake, the number of the dams, the area, and every information as to the quantity of water which may be obtained from it. There is one thing to be remarked, however, that the amount of water which may be drawn from the lake is considerably less than it might be, owing to the leakage. The leaks are, first, in the waste weir. In front of the waste weir a large quantity of soft earth was taken away to construct the dams. In fact, immediately in front of the waste weir there is a precipice, like a cliff almost, where the red earth, which would have formed the natural puddle bank, has been removed, so that a considerable amount of water finds its way through the ground. The waste weir was in a very much worse state before last season, when the repairs were undertaken. The whole of these works, I may say, seem to have been constructed in a very careless way, either from want of knowledge of the proper way to carry them out, or from actual carelessness and scamping. It is almost impossible to account for what we find to be the case on any other grounds. For instance, in the waste weir (which I found from the contract

drawings should have been founded on the solid) there was a very heavy leakage underneath, and when I looked at the contract drawing I wondered that how it could be so if the masonry had gone down to the solid. On opening out in front of the waste weir, I found the weir was founded, not on solid rock, but it had been laid on layers of stone and rubbish, such as might be washed down by the rains and left there. When this *débris* was taken away and a puddled apron was put in front of the waste weir and a puddle trench taken down five feet and joined to the solid, by far the larger portion of the leakage of the upper portion of the waste weir has been cut off. Leaving this material, which was really nothing more than a mass of stones, rubbish, and leaves, in a position such as this, showed either very great carelessness or total ignorance of the first principles of construction, which are, that all such works should be founded on the solid, and not on any such material.

Colonel TREVOR—Do you know what the section of the weir is inside?

Mr. AITKEN—Yes.

Colonel TREVOR—Was it not intended that the water should be cut off by a bank of puddle in the masonry?

Mr. AITKEN—The puddle could not have been down to the solid. I think it can be proved that this puddle trench could not have been down to the solid.

Colonel TREVOR—What is the height?

Mr. AITKEN—About ten feet.

Colonel TREVOR—Then even if there was a fault, it would not be a very serious consideration?

Mr. AITKEN—I am speaking more with respect to the quantity of water which runs through it. There was a guage put up there, and the water ran about six inches deep, and further down there was a very considerable leak. This last leak also has been somewhat diminished by this puddle trench. The waste weir is not in a dangerous state; in fact, if it did give way it would lower the level of the water in the lake down to 44 feet on the guage, or about 1/15 feet below the weir level when it would come to the rock, and there would still be a very large quantity in the lake.

Colonel TREVOR—Would it not be almost impossible for that waste weir to give way without giving notice?

Mr. AITKEN—It ought to give notice, but if you leave any material which is not water-tight underneath, it may blow up. It is a very remarkable circumstance that the work was not done according to the drawings. In proof of this I can call the Superintendent of the Works—who was always present—to confirm what I say, and I visited the works every two days during the time the repairs were in progress. The wall I expected to find in front of the waste weir was certainly not there. I believe also that the same reasons might account for some of the leakage in Dam No. 1. In Dam No. 1 there are two leaks. There is a leakage along the pipe which is supposed to have been caused by a chain which was put in there. It is not known definitely how it was caused, but it is supposed it was caused by a chain that was put in there to draw and hold together the pipes under the dam. It is not usual to withdraw such temporary appliances. I do not know what truth there may be in this report, but it was supposed that part of this chain was drawn out through the puddle, in order to save it. I can scarcely conceive that possible, but it is the reason alleged for the leakage. It was reported the other day by the Superintendent, that this leak had enlarged so much that the dam was about to blow up, as enormous quantities of water issued from the sluice house. It turned out, however, that the dam had not gone, but that some of the bolts of the breaches piece had blown out; the volume of water was so great that a man could not go near it. I fancy that the fact of the Superintendent, who is not a man to be easily frightened, reporting that this dam had blown, shows what the feeling in his mind was as to the state of the works. And I may add that the same feeling is entertained by every one connected with the works, namely, that the works are not in a satisfactory state. It is very unpleasant to have anything to do with the Vehar Works in the state they are now in. While I was in charge, they gave me very great anxiety indeed.

Colonel TREVOR—Have you any other instance to bring forward besides this?

Mr. AITKEN—Yes; I am coming to others. The other leak in Dam No. 1 is supposed to have come from some leakage in the original formation, or to come through the stones and rubbish which have most likely been left in on the bed of the stream. There is a very considerable leak at the foot of the bank.

Colonel TREVOR—I can contradict that statement, I think, because I saw the dam in course of construction.

Mr. AITKEN—There is some leakage there, and that is the only way that I can explain it.

Colonel TREVOR—It was carried out by the contractors according to the plans and specifications, and the puddle trench was provided for in these plans.

Mr. AITKEN—The question is, whether the material further up under the base of the dam was removed. This short puddle trench would probably not be sufficient ?

Colonel TREVOR—The work was done according to the specification by the contractors.

Mr. AITKEN—I know the puddle trench was put in the bottom, but there might have been a slight fissure in the rock, or through the material in the old bed having been left in.

Colonel TREVOR—Leakage from fissures in the rock was anticipated, but no danger is to be apprehended from that, you know.

Mr. AITKEN—No, perhaps not ; it is difficult to say. Dam No. 1 may be said to be in a sort of satisfactory condition, but not so satisfactory as it might be. Dam No. 2 has a very slight leak, but Dam No. 3 was certainly in the most dangerous condition I ever saw a water works dam in, and I have been connected at home with two reservoirs in a leaky state, which had to be strengthened. From the leaks in Dam No. 3, I may say that the water sometimes bubbled up in a stream as thick as three fingers, and comes through from one side to the other. There was a gauge put up to measure the quantity of water which came through—the guage was one foot wide. After the monsoon the water ran this guage about ten inches in depth. This of course was a very large quantity, and the worst feature in the leak was, that the larger leaks were all at the top. I believe when the dam was first made there were no leaks there. I am not sure whether I am perfectly correct, but I think there were no leaks in the upper portion of the dam. I do not know whether it is true or not, but I understand that one of the leaks, which afterwards became dangerous in the upper part of the dam, broke out after the work was taken over from the Contractors by Government.

Colonel TREVOR—I was at Vehar at the time when the water overtopped the bank and went over the waste weir. I think there was leakage going on from No. 1 Dam, and at No. 2 Dam a little water was flowing, but nothing serious either from No. 2 or No. 3. I went with General Rivers, the Consulting Engineer for Water Works, and saw the works. That was the first time the water overflowed the waste weir, and it has not occurred since.

Mr. AITKEN—It was when they raised the water four feet higher than the waste weir. That has never been done since, and I hope it never will be again. It was the most dangerous thing that could have been done.

Colonel TREVOR—I remember distinctly going over the works and seeing that the water was only about four inches over the weir.

Mr. AITKEN—Perhaps they had removed the planks at that time ?

Colonel TREVOR—Perhaps—it is possible.

Mr. AITKEN—This dam has always been a matter of dispute. The lower portion of the dam was constructed by the Public Works Department, and the upper portion, where the leaks spring from, by the Contractors, Messrs. Bray and Chapman. I am sure I cannot account for these leaks springing up, except on account of bad work, the work being hurried, and the whole of the material which was removed from the dam instead of being put in from the inside in six or nine inch layers, as it should have been, appears to have been put in layers of two or three feet. And the consequence was, that when the material was thrown down the larger particles ran to the bottom and made a sort of layer of unequal density. I know we found that the material was well compressed at the top, and that lower down it was very open, indeed, in these thick layers.

Colonel TREVOR—What is the height of that dam ?

Mr. AITKEN—42 feet.

Colonel TREVOR—And the greatest pressure ?

Mr. AITKEN—36 feet.

Colonel TREVOR—Is the lower part of it sound ?

Mr. AITKEN—Yes.

Colonel TREVOR—You mentioned just now that there were leaks at the top : how far are they from the top ?

Mr. AITKEN—One of them is about 10 feet below the level of the water at the height of the monsoon.

Colonel TREVOR—Then it is only under a 10-foot pressure ?

Mr. AITKEN—Yes; if it had had a greater pressure it would most probably have given way. The danger of a work of this kind is not, I take it, the want of thickness, it is the danger of the hole enlarging—thereby the velocity will increase, and the hole will still further enlarge.

Colonel TREVOR—There are a great many dams in India, and 30 feet is small, is it not? The pressure of 10 feet is so slight that even earth without puddle would stand it?

Mr. AITKEN—Yes; but the leaks were increasing from year to year. I can't form any opinion as to the cause of the leaks, except that the bank was badly constructed; and the fact of the leaks increasing showed that they were dangerous. If they had gone on increasing largely they would have become unmanageable, for the velocity of the water would have sconced everything out of the dam. The repairs which were carried out were not quite as recommended by the Commission appointed by the Government, because, as explained in my annual report to the Commissioner, after the water had gone down we found many of the leaks were still in active operation, showing the source of leakage was further down; and as we could not get down the puddle apron further, we put down a puddle trench, and that intercepted the leakage. Of course now there is a certain amount of leakage, but it must be below the puddle trench, and so deep in the solid part of the dam, that I don't think there is any reason to apprehend danger to Dam No. 3 now.

Colonel TREVOR—When were these repairs carried out—in 1867?

Mr. AITKEN—Yes.

Colonel TREVOR—The water fell 11 feet that year?

Mr. AITKEN—Yes.

Colonel TREVOR—And the whole depth of the water at the time was only 11 feet?

Mr. AITKEN—Yes; and the danger of the leak was that if it had begun at the top, it would cut its way down to the bottom, as was the case at the Holmfirth dam.

Colonel TREVOR—It is very small, only 11 feet?

Mr. AITKEN—I think it was merely a matter of time. In a very short time the velocity of these leaks would get so great as to scour away the red earth of which the dam is composed. I may say that repairing a dam, unless you can remove the water, is one of the most risky things any Engineer can undertake. I never before knew any case in which a dam had been repaired without removing the water. When I was a pupil on the South Staffordshire Water Works a dam there showed some signs of leaking, and the water was run off, and after the dam was repuddled the water was re-admitted again, and the dam was found to be perfectly safe; but repairing a dam such as this is very anxious work, and if it had to be done again, I must say I should not like to undertake it. I have been fortunate as it has happened, but it was a very great risk.

Colonel TREVOR—I don't think it would have been a very serious thing even had it failed.

Mr. AITKEN—I should say it would probably have killed 2,000 or 3,000 persons down at Coorla and it would certainly have killed all the people in the Poway valley; in fact, there is no knowing how many people would have lost their lives, besides damage to property. But the damage to be anticipated is nothing compared to the ultimate consequences. Bombay is now supplied with water chiefly from the Vehar Works, and the loss of this water would represent a loss of life in Bombay which it would be difficult to estimate. If you take away 40 feet from the top of the Vehar Lake you would get only a fourth part of the water left. This water at the bottom of the lake is very foul indeed, and if people had to drink it I think it is very likely cholera would break out, and the place would be decimated.

Q. Do you think the pipes of the Vehar Works are rather too thin?—A. Yes; the main is liable to burst. The thickness of course is theoretically ample for the pressure the main has to stand, but when you take pipes on board ship they get knocked about so and strained that they are very liable to give way; even now they give way sometimes without good reason.

Colonel TREVOR—Would not they be liable to do so anywhere else?

Mr. AITKEN—No; on the South Staffordshire Works we had 24 miles of pipe and a pressure of 300 feet and no breakage.

Colonel TREVOR—Then you got your pipes close to the works?

Mr. AITKEN—Yes; it is the carriage from home which makes the danger.

Colonel TREVOR—Do you think increasing the thickness of the pipes would remedy that?

Mr. AITKEN—I think they are less brittle, there is more metal and they cool slower.

The CHAIRMAN—What is the average breakage of the pipes along the main in a year?

Mr. AITKEN—The water is perhaps shut off three days in the year from breakage of the pipe. Then again the joints sometimes give way, but that is not the fault of the pipe.

Colonel TREVOR—To keep the main in order you require to shut off the water for three days in the year. Is that a large average even in England?

Mr. AITKEN—In England you generally depend on making repairs when the water is shut off for

other purposes. I do not know that the water is often shut off owing to breakages. In the South Staffordshire Water Works the water was pumped up into different reservoirs. There was, I believe, no breakage for the first year.

Colonel TREVOR—That is nothing very serious?

Mr. AITKEN—No; I don't think it is a sufficient reason for laying down a second main because the water is shut off for about three days in the year. The pipe must be shut off at any rate to make new connections with the main, and such things. There is 8,195,000 gallons coming down in a day, but during the night there is very great pressure in the pipes at Bombay. If Vehar was only used to supply the low-lying portions of the city, a pressure of 80 feet at Bycullah would suffice, and we could get about 25 per cent. more water from the main than we do now. If you look at the table in Appendix C, the pressure varies from 60 feet to 130 feet, but that is when the water is shut off to supply Malabar Hill and the troops at Colaba. If we could work it at 8¢ feet we should bring 25 per cent. more water from Vehar than we do now, but as the water is not in the lake, it would be a waste of money to lay a second main.

Colonel TREVOR—If you had a small steam-engine at Tardeo you might get 25 per cent. more water, and a constant supply for Malabar Hill, could you not?

Mr. AITKEN—No; there is the Fort and Colaba.

Colonel TREVOR—They are low-lying.

Mr. AITKEN—Yes; but by the time the water got to the Fort, the drawing of it off in the town would take off the pressure. At the Town Hall the water is only 37 feet above mean sea level just now. We can't get water down at Grant's Buildings in the day time. I think, on the whole, and I have said so in my report, that I don't think a town should be dependent upon such works as the Vehar for its sole supply of water.

The CHAIRMAN—You give an estimate of two lacs for strengthening the dams and waste weir. Do you think if that is done, the dams can be made reasonably safe?

Mr. AITKEN—Yes, I should think so; and I think Dams Nos. 2 and 3 might be made equally safe. The only awkward part is putting in the puddle trench behind the present one on account of the number of leaks at the foot of the dam through the solid. I think when you are putting in the puddle trench the water would rise between the new puddle trench and the old bank, so that it would be troublesome; but I should not anticipate any difficulty in doing the work. I think if two lacs was expended on Dams 2 and 3 they might reasonably be considered as perfectly safe, but there still would be a danger of the pipe underneath Dam No. 1. Although it has not shown signs of increasing, yet it might do so at any moment.

The CHAIRMAN—Has any means of checking the leak in No. 1 occurred to you?

Mr. AITKEN—No; the water tower is defective, and you can't shut out the water from the pipe underneath the dam.

The CHAIRMAN—Then it would be impossible to get in to line the pipe?

Mr. AITKEN—I am afraid—quite impossible; at least in the present state we can't get in. We ought to be able to do so, but there is a hole, or holes, in the water tower where the water rushes with very great force indeed. I don't say the tower could not be made tight, but we never had occasion to shut off the water. The holes must have been either caused by carelessness or from a stone blowing out, but we have never been able to get in to the 40 inch pipe. Mr. Pyne, the Superintendent, has tried, but never succeeded, for the pipe is generally three-quarters full.

Colonel TREVOR—Could you not put in another pipe at a higher level?

Mr. AITKEN—Yes; the pipe should be put in between Dam No. 1 and the waste weir; there it might have been tunneled very nicely through the solid, and even now it could be put in at a higher level.

Colonel TREVOR—I see you never go below 43 on the guage?

Mr. AITKEN—You might get two or three feet below that by putting in a coffer-dam.

Colonel TREVOR—And you might increase the height of the dam to any extent you desire.

Mr. AITKEN—Unless you make works satisfactorily at the beginning I don't think anything would stop a leak of that kind. The great axiom with respect to water works is to make them right at first, and then you have no trouble afterwards.

The CHAIRMAN—It is the rule in everything, I think.

Mr. AITKEN—While you are throwing in earth the leak is still going on, and there is a current of water running through, and I should think it exceedingly doubtful, with a quantity of water coming in, whether you could stop the leak. It might be done, and might not; there is no certainty.

Colonel TREVOR—Has not something of that sort been done ?

Mr. AITKEN—In the Staffordshire Canal we used to get cow dung and horse dung and straw litter, and then throw puddle on that; but there was not 60 or 80 feet of water.

Colonel TREVOR—But we have only 10 feet here.

Mr. AITKEN—Not in the case of the leak under the outlet pipe. I may say that the great danger of a leak in a dam is that it acquires such a size before any assistance can arrive. No one can live at Vehar but the natives themselves : it is so unhealthy ; and if a leak broke out, the Superintendent, when he was called, would probably meet the water coming towards him, and the whole thing would be gone before he could get there.

Colonel TREVOR—Is that a common thing ?

Mr. AITKEN—Leaks don't spring up suddenly, but they widen suddenly ; and if you have a leak in an embankment you never can tell what form it may assume in 24 hours. I don't think these works have been done with care, and as far as I can gather from the persons who have second-hand knowledge of the subject—for I believe every European who was engaged on the works has either died or left the country shortly after—the works were not constructed with the care such works demand ; and I say, from what I have seen from these works in Dam No. 3 and the waste weir, that my non-experience quite agrees with what I have been told.

The CHAIRMAN—Supposing you strengthen the two dams as you suggest, at a cost of two lacs, could you bring in the water by Scheme No. 3—the Toolsee scheme—without any danger to the embankment ?

Mr. AITKEN—Oh, yes ; I think so.

The CHAIRMAN—And carry it into Bombay by the existing main ?

Mr. AITKEN—No ; you would require another main.

The CHAIRMAN—Would that give you 25 per cent. more water ?

Mr. AITKEN—It would give six gallons more per head—would increase the supply about 50 per cent. There is one objection to the Toolsee scheme, that the lake would be drawn off 25 feet instead of 13 feet, and the more you have water going up and down in the lake the worse it is for the banks, for they are subjected to varying pressures.

Colonel TREVOR—In your report I see you mention that it is exceedingly difficult to get any information as to the cost of the work. If you had asked the Accountant General he would have told you.

Mr. AITKEN—I have enquired all through the municipal offices of everyone I could think of, but it never ocurred to me to go to him.

Colonel TREVOR—I think you will find the work was all done at contract rates.

Mr. AITKEN—I have no doubt the accounts are all correct ; but what I mean to say is, that when they were constructed the price of labour was very much less than it is now. I consider there was very little done for the amount of money which has been expended.

Colonel TREVOR—Have you ever seen the rates ?

Mr. AITKEN—I have heard of them, and they are very high.

Colonel TREVOR—Higher than those charged by contractors now ?

Mr. AITKEN—I think some of them quite outrageous; some of the extras allowed were quite uncalled for.

Colonel TREVOR—What was the result to the Engineer ?

Mr. AITKEN—The result is that you cannot account for their enormous cost.

Colonel TREVOR—The instance you refer to led to the dismissal of the Engineer.

Mr. AITKEN—But there were several instances when very large prices were allowed for mere nominal work. I may say in the estimate of Scheme No. 3 the estimate of two lacs is not included in it, so that it would make 18½ lacs.

The Commission then adjourned till Monday, the 29th.

FOURTH DAY. MONDAY. MARCH 29.

The following Commissioners were present—

ANDREW R. SCOBLE, Esquire, *Chairman.*

Colonel KENDALL, R.E. | Lieut.-Col. TREVOR, R.E. | Dr. HUNTER.

Dr. LYON, *Secretary.*

The Commission resumed at 2 o'clock on Monday, in the Durbar Room, Town Hall.

MR. RUSSEL AITKEN *resumed* :—

Colonel TREVOR—With regard to the Vehar Lake, would not it be possible to build a wall behind the dams and thus to strengthen them ?

Mr. AITKEN—The danger is that you have such a limited time.

Colonel TREVOR—But behind the dam there is no water at all.

Mr. AITKEN—You could not get people to work during the rains there.

Colonel TREVOR—Would not the building of walls effectually close the chance of failure ?

Mr. AITKEN—Of course, if it were well done it would ; but the danger of reservoirs is that when once they break away they begin by a slight break.

Colonel TREVOR—Would not that be put an end to if a wall were built ?

Mr. AITKEN—Yes ; but I don't believe in masonry walls in India.

Colonel TREVOR—Not in addition to this immense earthen dam ?

Mr. AITKEN—Exactly ; but I don't believe in masonry dams in India. I think the danger is that you would be likely to have bad work.

Colonel TREVOR—Colonel Fife has built a wall 80 feet high, and he advocates such walls.

Mr. AITKEN—I should not like to advocate such a work as that with native labour. I think there is great risk.

Colonel TREVOR—I do not see how it can fail.

Mr. AITKEN—The bund at Poona gave way three times.

Colonel TREVOR—That was in the bed of the river, and the water flowed over it.

Mr. AITKEN—But it was founded on rock, and there was no more pressure on it than there would be on a dam.

Colonel KENDALL—That was bad masonry, but that was a totally different thing from what Colonel Trevor was proposing. It was carried away by the water flowing over it.

Colonel TREVOR—It was certainly bad masonry. There are hundreds of such dams in this country.

Mr. AITKEN—What I maintain is, that there is great extra risk and danger in all such works. As to the distribution of water in the town, while I was in charge of the works I endeavoured to the utmost of my ability to design something which would supersede dipping wells, but I was quite unsuccessful. I could not conceive anything. The stand pipes are almost always out of order, and I do not see any efficient means of replacing the dipping wells. Stand pipes are only suited to places where there are very few people living. At Pydownee you would require to fit up about fifty cocks, and the difficulty of keeping these tight would be very great. It may perhaps be suggested that iron buckets should be placed at the dipping wells, and the use of them made compulsory, so as to prevent the people from dipping with the foul vessels they often use. As to the surveys for the extension of the works, after it was determined to abandon the catch water drain as being insufficient to meet the requirements, the

first thing was to explore all the valleys in Salsette. The result of the surveys at Canery, Toolsee, and Poway are given in my report. The Ewoor Valley, immediately behind Tannah, was also surveyed and contoured and sections taken for the dams, and we found that we could get a dam there and a reservoir of 560 acres, with three dams, about 96 feet high. But there was no collecting ground. I had thought it might have been possible to get some side streams to fall into it, but when we came to survey them we were obliged to give up the idea of a reservoir there altogether. The whole extent of gathering ground and reservoir they could have got there was only 960 acres, so that it would have been quite insufficient. After the Ewoor Valley had been surveyed, the survey parties moved on to the mainland, thinking they might find a reservoir in the immediate vicinity of Tannah. The survey parties moved up to Bhewndy and Kamaun. Kamaun was found to be very low, and there was no place for a dam. At Satoola it was also very low, and the tide went right up to it, and there was no place for a reservoir there. The survey parties then went to Tambewly, three miles from Bhewndy, but the tide went up as far as that, and they found that river rose so rapidly that there was no area to give the necessary quantity of water, so that place was abandoned. The tide goes up to Bhewndy, and that place would not answer very well, for a low level dam would require to be about a mile and a half wide, so that that place had also to be abandoned. Tansa River, at Atgaum, was also examined, but there was not sufficient storage ground. That river, like many of the rivers there, cut in through the surface of the ground for about 60 feet deep. There was a large river called the Bathsey River, which also was looked at, but the main objection to that large river was the enormous quantity of water which came down. The Bathsey drains about 283 square miles, the slope is very considerable, and the rainfall being great, the velocity of the river was something frightful. The water brought down an immense quantity of shingle, and if a dam were built there, in a short time it would be silted up. Although on the plan the country seems to be ranges of hills, the plan is somewhat exaggerated, as all surveys are. This plan is a copy of the Revenue Survey. The ground slopes gradually from the Ghaut, and is divided and intersected by detached ridges. For instance [pointing to the plan] although this one may be 400 feet high, there may be opening through it only 80 feet above the bed of the stream. I would have located a line of pipes for the Shewla scheme if it had not been so, but so many lines would require to be surveyed that it would not have been satisfactory. So that these hills, although they appear continuous, are not so in reality, and the plateau is cut by these rivers, which, as I said before, in many places have cut about 90 feet below the general level of the ground. The beds of the rivers are on an average about 40 or 45 feet below the level of the ground, and of course that at once destroys any hope of getting a large reservoir with a shallow dam. In fact I scarcely think it would be possible to manage the works on a river such as the Kalloo, draining 288 square miles, owing to the floods and the silting up. The Kalloo River is 600 feet wide, and the water in it when the tide is high is sometimes 40 feet in depth. The waste weir for a river of that kind, if a dam was built, would require to be about 3,000 feet long. And I think the Bathsey and Kalloo Rivers would have to be abandoned, as the dam would require to be very high, and we could not impound a quantity of water which would be commensurate with the cost of the weir. The dam, too, would require to be of masonry. For instance, suppose I tried to put a dam on the Kalloo, where Captain Tulloch put a mark. If it had risen 60 feet, it would have flowed over through here (pointing to plan).

Colonel TREVOR—There does not seem to be any useful object to be gained in damming up the river.

Mr. AITKEN—No; but Captain Tulloch proposed——

Captain TULLOCH—I did not make any proposition. What I say is that it is not necessary to go as far as Shewla, and that is all I have said definitely.

Mr. AITKEN—I am giving my reasons why we must go to Shewla.

Captain TULLOCH—It would simply be absurd for me to say we should dam up the river; but we can get a dam nearer than Shewla, and I hope to be able to prove it.

Mr. AITKEN then proceeded—Kalloo River cuts into its banks about 45 feet in some places; and suppose we were to put down a dam 45 feet high, the water would overflow and block up the railway. Then with regard to the Oolassa River, the tide rises in the river for about a mile and a half above the Railway Bridge. No doubt we might put in a dam there, but what would be the result? The G. I. P. Railway, a little below Budlapore Station, is 53 feet above mean sea level, and river floods rise 20 and 21 feet, and thus the floods will be about 44 feet above mean sea level. The railway being 53 feet, there is a difference of 9 feet, which is just sufficient for extraordinary floods to pass off without inundating the railway. If a dam 50 feet high were put down, we would have a very unsatis-

factory reservoir—a long, shallow, and irregular reservoir, varying from five to ten feet deep, in which weeds would grow and would make the water very foul. Then the Oolassa drains 480 square miles of country, inhabited by a large number of people, all of whom would require to be turned off if the water is to be preserved in purity, and I do not think it desirable to take the water for the supply of a city from the drainage of such a large district as 480 miles, on which a large population is located. By putting a dam down, as suggested by Captain Tulloch, we would necessarily flood the Great Indian Peninsula Railway for six or eight miles, which is out of the question. I merely mention all this to show that the whole of these places have been surveyed and considered, and that I do not think there is any reason to suppose that it will be possible to get a reservoir on any of these large rivers. In these districts 300 inches of rain falls on the Ghauts during the monsoon, and 100 inches on the lower portions, and the quantity of water in these rivers is so enormous that the control of it would present great and serious difficulties, such as I would not like to undertake. After these rivers were surveyed the survey parties moved up towards Matheran, because there I understood there was a possibility of getting a reservoir; but although we got almost everything at Matheran which could be required, the area of the reservoir was only half a square mile, or about 350 acres. Afterwards we moved up to the Moorbaree River at Tonlee, where we found a reservoir of more than 2,000 acres, but the dam was very much longer than the Shewla one, though the storage was less. Afterwards the survey parties moved up the Oolassa River, and we got at Kurjhut apparently a very fine site, but to begin with there was no catch water area. It is the large gorge you see on the railway, to the left, on the Bhore Ghaut. You observe from the totals at the end that the gathering ground at Shewla Lake is proportionally rather in excess of Vehar. There is 12,000 acres of gathering ground, and 4,000 acres of a reservoir, so that the gathering ground is 3 to 1.

The CHAIRMAN—The 12,000 acres are exclusive of the reservoir?

Mr. AITKEN—Yes, it is rather less than 3 to 1, and at Vehar 2 to 1. As the rainfall on the Ghauts, I believe, has never been known to fail, that is another element in favour of the Shewla scheme. Having found a site for the reservoir at Shewla, the question was, what is the best way of taking the water from here to Bombay? I may say that after passing Callian, I came to the conclusion that if a high level reservoir could be got, it was hardly worth while to waste money in surveying the country for a low level reservoir. The reason is, you must have several very heavy aqueducts on the road between Callian and Bombay. The water, if it is taken from a low level reservoir, would require to be taken in a covered aqueduct. I do not think it would be at all proper, or at all in accordance with modern practice, to have open aqueducts; in fact I think they have been almost universally abandoned now, even although the substitution of covered aqueducts increases the expense of new works. Again, as there is a large travelling population on the line which any aqueduct must take, I do not think it would be quite safe to have this long line of aqueduct exposed. I think it is likely that the water would get very foul before it reached Bombay, and so form a source of disease. Having thus, in my own mind, settled that the aqueduct must be covered, I come to the conclusion that, taking water in a covered aqueduct from the rear of Callian from any low reservoir, and then pumping it up at Bombay, would be much more expensive than taking it from a high level reservoir situated on the hills, and thus doing away with the necessity for pumping. The element of pumping is one on which I suppose there is more difference of opinion than on almost anything else. It is one of those things on which you can work out the most elaborate results in figures, but it is only practical conclusions which have any weight. For instance, let us take the case of the Shewla reservoir supplying 25 million gallons of water at a pressure at Bombay of 80 feet above the mean sea level. If this water were brought down from any place behind Callian at low pressure, it would, as the ground near Callian is very low, most likely find itself in Bombay at a level of 20 feet below the mean sea level, so that it would require to be pumped 100 feet. So that to pump 25 million gallons daily would necessitate the continuous working of engines of 530-horse power. Now engines in India are not really what they are at home. Coal is very much deteriorated here—as much as 15 or 20 per cent.; the vacuum is never so good, great waste takes place in stoking, and the cost of labour and superintendence is much higher than in England. We want 530-horse power, and we know very well that none of the engines of mills in Bombay work at less than six pounds of coal to each horse power. Mr. Macdonald, who is a very able mechanical engineer, tells me the average is certainly above 7 lbs. But I am now taking a favourable case. 530-horse power must be continually employed in working the pumps all the 24 hours, representing, at 6 lbs. of coal per hour per horse power, a consumption of 34 tons per day. But supposing we take Captain Tulloch's figures as given in one of his pamphlets, where he states as his opinion that we could get 50,000,000 foot

pounds from the consumption of one cwt. of coal, so that to raise the 25 million gallons one hundred feet high would require an expenditure of 25 tons of coal. For the sake of argument let us suppose that to pump 25 million gallons 100 feet 30 tons of coal would be daily required; 30 tons at Rs. 33 per ton would give Rs. 3,62,150 per annum for cost of coal alone. That capitalised at 5 per cent. would give Rs. 72,27,000. Suppose we take the cost of superintendence, wages, oil, and depreciation at Rs. 50,000 per annum, which is very moderate, we thus have a further capital of Rs. 2,50,000. Then we should of course require spare engines, and to lift 1 million gallons 100 feet high the amount of engine power required at the various waterworks in London varies from 32 to 90-horse power; if we took a mean it would be about 50-horse power, and for 25 millions that would give 1,250-horse power. Mr. Simpson, who is most reliable, makes it a quarter more, or nearly 1,500, let us say that engines of, say 1,400-horse power. These are the engines which would be required from home to do this work. At Rs. 900 per horse power, 1,400-horse power would be Rs. 12,60,000. With engine house and so on it would come probably to about 15 lakhs of rupees for engines, which, together with the capitalised cost of coals, 72½ lakhs, and the capitalised cost of labour, 2½ lakhs, would represent altogether 90 lakhs. Of course there is the cost of a covered aqueduct, which I believe would under the most favourable circumstances be about Rs. 1,30,000 a mile. Taking 56 miles of stone aqueduct at Rs. 1,32,000 a mile, that for 56 miles would give Rs. 73,92,000. The aqueducts over or under creeks would cost 3 lakhs of rupees. If there was a covered reservoir in Bombay to contain two days' supply, which might or might not be necessary, that would cost 15 lakhs of rupees. The whole thing would cost about 182 lakhs of rupees. There is one very great objection, I think, to the use of pumping engines, which is the very great amount of supervision that they necessitate. These things seem to go on very nicely at home, and one has no bother with them. I know that in South Staffordshire—at Lichfield—the water was pumped from a considerable depth and the engines worked steadily. In the pumping at Love Grove, the men in charge at night go to sleep, and the fires go out. It is, I think, most desirable to avoid a complicated system which necessitates large pumping engines—that is to say, if their use can be avoided. All new waterworks have been as far as possible designed to deliver water at a high level;—for instance, the Brooklyn waterworks, the new waterworks at Glasgow; and Mr. Bateman's last proposition is, to supply London with water from a height 250 feet above Trinity waterworks. But London is much higher than Bombay, and therefore, of course, the height of the reservoirs must be greater. If it had been possible to bring water from Shewla in a cast iron pipe, I should have preferred to have stuck to the orthodox iron; but a cast iron main, when you have got it up the country, including the expense of the carriage, would cost about three times as much as the main I propose, although the home cost of the steel main —⅜ of an inch in thickness—would be the same as a cast iron main 1⅛ inches in thickness; yet when you come to add the cost of carriage, and the landing charges, and the expense of taking such large pipes up-country, I think the cost of iron mains would be about treble the first cost of the proposed steel main from Bombay to Shewla. Of course I considered the subject of wrought iron, but wrought iron would require to be very much thicker, at least one-third thicker than steel. It would have been rather cheaper than steel at home, but the extra cost of carriage would make it much more expensive before it could be delivered on the ground. As there was only steel left, I did my best to make an honest, straightforward estimate. Mr. Ormiston seemed to think my price for steel was too little, but here is a circular which I have received from home, in which the price for Bessemer steel is quoted at £17 per ton. The cost of steel rails has within two or three years gone down from £18 to £11-10 per ton, so that the price of steel is rapidly falling.' Of course, this "price list" gives £17 per ton as what they call the "trade price," and includes the price at which the merchant buys the steel from the manufacturer, then the merchant sells it to you, and he gets a large profit; generally, the trade cost price varies from 15 to 20 per cent. from what you can get it from the manufacturer. For instance, I know that we have a new system of indenting for drain pipes from home, by which we get them direct from the makers 30 per cent. cheaper than the trade price list gives. I think steel plates cost from £14 to £15, and the amount of labour employed in their manufacture is very trifling, for you can put down twenty plates and drill them all at once with the same set of drills. I think the price I have given is quite within the mark, for steel is decreasing in value—and that so far from its being under-estimated, the price I have stated is quite ample. In a proposition such as this, a similar proposal never having been made before, the item would require very careful consideration from the manufacturers and those who had to carry

out the work. But I am not particularly afraid of trying new schemes when the necessities of the case call for them. But I do not think this is what you would call anything so entirely novel as to make any contractor hesitate undertaking the work and guaranteeing it, besides leaving him a good profit. I am perfectly certain the prices I have given are very fair, and that the contractors would make a very handsome profit out of the work. As to the thickness of the material, I think that also is ample. The greatest pressure on the main would be at a point on the Oolassa River, where there would certainly be a pressure of 140 lbs. This is certainly not a greater pressure than that at which locomotive engines are worked, and locomotive engine plates are not thicker. I think that with proper arrangements for rivetting the joints it would be perfectly safe. Then again it may be said that there are objections to the rise of every new material, more especially when you try to use such thin material. If you go to Love Grove you will see a boiler seven feet in diameter and five-sixteenths of an inch thick, which is to work up to 80 lbs. pressure. I think it has been tested at home up to 150 lbs., and of course the strain on the boiler is much greater than the pressure would be upon the mains, so that I really do not think there is anything so very alarming in this proposition. There is always an objection to using new material in such a large quantity as this, but I think we have got over all the difficulties in the way of using steel. Mr. Ormiston, the other day, said that Mr. Reed gave his opinion against the use of steel for making iron ships, but Lloyd's have shown their appreciation of the value of steel, as Mr. Reed says in his own work, by reducing the scantling allowed on iron ships by 30 per cent. Mr. Fairbairn in the account of his experiments gives the strength to steel at one-third more than that of wrought iron. There is no doubt whatever that steel is practically one-third stronger than iron; and it is less liable to corrosion from wet, and does not scale away in the same way that wrought iron does. In fact steel boiler tubes last very much longer than iron ones. I have no data to go upon, but I believe the engineers of the Manchester Boiler Association have come to the conclusion that steel stands very much longer than wrought iron for boiler tubes where exposed to all varieties of temperature and where the strain is very great indeed. Of course I cannot get quit of the argument that this is a new proposal. If it is impossible to take the water down to Bombay for Rs. 1,40,00,000, as proposed, I say that the water cannot be taken economically in a low level aqueduct and pumped. I think the best and cheapest thing we can do is to take the water from Shewla by a steel main.

The CHAIRMAN—Mr. Ormiston said that in calculating the tonnage per mile you had not made any allowance for overlapping.

Mr. AITKEN—Yes, I made the usual allowance, seven per cent.

The CHAIRMAN—Do you think that would be sufficient?

Mr. AITKEN—I think so; I would not put in many strips except butt strips.

The CHAIRMAN—Mr. Ormiston also thought that you did not allow enough for laying, rivetting, and fixing, which you said would cost only Rs. 30 per ton.

Mr. AITKEN—Well, that is a matter for the contractors. We get our roofs put up, corrugated iron roofs, for Rs. 22 per ton. I have consulted with Mr. Macdonald about this price, and there is no intention here of under-estimating anything. They are very convenient plates for rivetting; there are only two plates to be rivetted together. And I don't fancy it would cost more than Rs. 30 per ton. You would find some contractors who would want more, and some who would do it for less. As to the cost of carriage, 2 annas per ton per mile is the usual charge on the G. I. P. Railway.

Colonel TREVOR—I think the Company would do it at 8 pies per ton per mile.

Mr. AITKEN—I think 8 annas per mile for cart carriage is a very fair rate. In Bombay we get it done for 6 annas per mile.

The CHAIRMAN—Part of the ground is very rough.

Mr. AITKEN—But a new road is being made.

Colonel TREVOR—Yes, but that was going to be made seven or eight years ago.

Mr. AITKEN—When I was there last year an engineer was stationed there.

Colonel TREVOR—That was the Local Fund Engineer.

Mr. AITKEN—He was laying out a pucka road 30 feet wide.

The CHAIRMAN—Then as to the paint?

Mr. AITKEN—I think that is put down at a very fair price. The main might be tarred.

The CHAIRMAN—I want to know how you make out 56 miles. Does that 56 miles allow for inequalities of ground?

Mr. AITKEN—Yes. I started with taking the railway length, and I do not think the railway people are likely to under-estimate the distance. I think the distance must to a certain extent be approximate. It might be two miles less or half a mile more. However, as I said, the country does not consist of ranges of hills, but there are several routes which the pipe might take, so that I did not care to mark any one on the map. All these levels were taken by two sets of surveyors, who both started from the railway and worked back to the railway, and though the levels did not correspond to a mathematical nicety, they were all checked to within a foot or so of each other.

With regard to the smaller schemes—Canery, Toolsee, and Poway. The Canery scheme appears to be the most advantageous, and the only objection to that is the height of the dam. I don't pretend to underrate the necessity of very great caution and very careful superintendence in a work of such a great height. I know no instance of such a high dam; but I should not anticipate any difficulty in making it. The formation on the whole of Salsette and the Konkan is red earth overlying trap rock, and the rock is very near the surface except on the beds of the streams where there is a quantity of gravel and boulders that would have to be taken away. I think Colonel Trevor slightly misunderstood me the other day. What I meant to say was that I did not think the gravel and boulders had been taken away from the whole of the bottom of the dam, but I had no doubt the trench was put in properly. I do not think it is desirable to depend entirely upon the puddle trench.

Colonel TREVOR—In making tanks in this country I don't think we indulge in puddle trenches.

Mr. AITKEN—Of course when I said No. 1 Dam, I meant the whole of the gravel and shingle underneath the bottom of the dam, and I think the puddle trench is a very necessary precaution, and one which should not be dispensed with.

Colonel TREVOR—I think there was a deep trench.

Mr. AITKEN—There was a deep trench, but I doubt if the whole of the gravel was taken away. I can only account for the leakage in Dam No. 1 in that way. Of course a puddle trench is a very slight thing to trust to.

Colonel TREVOR—I remember seeing a trench, but I cannot say whether it extended over the whole length of the dam or not.

Mr. AITKEN—The Vehar dams, although they are tight enough as far as they go, were done in layers of two feet.

Colonel TREVOR—All I can say is that they were carried by women in baskets. I don't think there were any regular layers.

Mr. AITKEN—I know when we were repairing Dam No. 3 we could distinguish the layers by the different colours of the earth two feet thick. As to throwing water all over the layers, Mr. Pyne tells me another story altogether. He says what he heard was that they kept a good look-out, and when they saw any one coming they worked very well, and plenty of water was put on.

Colonel TREVOR—Well, nobody can say. I only speak from what I saw, and there were no rumours then about scamping.

Mr. AITKEN—That was what was reported to me.

Colonel TREVOR—I never heard it stated that the dam had been scamped, although there were lots of rumours about.

Mr. AITKEN—I don't think the leakage of these dams should deter us from making Canery reservoir, especially as all the serious leaks were at the top of the dam. It is quite true that as the water is deeper the pressure increases on the dam, but it should also be remembered that the weight of the dam increases very greatly also. A column of earth 140 feet high would have a pressure on the base of not less than 7 tons, which is as much as is usually put on ordinary brick work; that would make it very compact, and I don't think looking to it that there is any risk attending on the construction of a dam of that kind, more especially as there is trap rock through which you can take the outlet pipe, and as the waste weir would also require to be tunnelled through. The waste weir has been taken at 800 feet long.

The CHAIRMAN—In the Canery scheme you don't intend to take the pipe through the dam at all?

Mr. AITKEN—Tunnelled through the rock below the dam there will be about 40 feet of solid rock between the dam and the pipe.

The CHAIRMAN—I want to ask you whether in making the dam at Canery you purpose to put puddle inside the pitching of the dam?

Mr. AITKEN—I think if the dam is made in six-inch layers, kept well watered, it would not be necessary.

The CHAIRMAN—Does not puddle lining of that sort very much strengthen the dam?

Mr. AITKEN—It holds the water as we know, because No. 3 Dam of the Vehar Lake depends on that puddle facing which was put in by me. It might be an element of safety which could easily be made.

The CHAIRMAN—Do you agree with Mr. Ormiston's proposal to put a berm of 50 feet outside?

Mr. AITKEN—There is no harm in it, but I think the dam amply strong enough, and if properly constructed I should not anticipate the least danger.

Colonel TREVOR—Did you ever work out the cost of making a masonry dam below these three?

Mr. AITKEN—I am afraid it would be very heavy. If you look to the small one we have got for Toolsee, that is only 35 feet high, and it is a very short one. The cost in estimate Rs. 1,30,000, and I am afraid it would come to a great amount, that is for cement.

Colonel TREVOR—Your opinion is widely different from Colonel Fife's, for he considers a masonry dam, if a certain height, is cheaper than an earthen one.

Mr. AITKEN—I have got my doubts about masonry dams in this country. I should be afraid of them even with the very best supervision. This estimate is for cement, and I would not attempt anything in mortar at all.

Colonel TREVOR—You attach greater importance to cement than I do. We have built a great many reservoirs and weirs, and they used to stand very well with the old mortar of the country.

Mr. AITKEN—You can make very good mortar of course.

Colonel TREVOR—There are weirs in India 30 or 40 feet high and about a hundred years old, and the water flows over some of these weirs to a depth of 10 or 15 feet, and they are made of nothing but the common chunam of the country.

Mr. AITKEN—I am afraid they took more care then than now in its preparation. If a man got his head cut off now and again for supplying bad chunam as he would have then, it might remedy the evil; but the present chunam, unless you make it on the works, is not good and is much adulterated.

Colonel TREVOR—It is always the rule to make it on the works. I don't think you have given us any description of the method in which you propose to construct the 136 feet dam.

Mr. AITKEN—Yes, you will find it. In layers of red earth and clay not exceeding six inches in thickness and trampled with plenty of water.

Colonel TREVOR—And what was the specification of Vehar Lake?

Mr. AITKEN—I have never seen it, but I think it must have been done in layers of two feet thick. I know Dam No. 3. I am sure it was done in thick layers, because I saw the red earth in one layer and the yellow earth in another, and there were stones there just as if they had rolled down the slope.

Colonel TREVOR—Do you think you would be able to ensure much better work at Canery than you have at Vehar?

Mr. AITKEN—Well, it is very difficult to say; but I think you should get fair work done by paying properly for it and having respectable men. The great point is the selection of men upon whom you can depend.

Colonel TREVOR—I think the Vehar dam is 90 feet.

Mr. AITKEN—85 feet. Of course the puddle trench is about 20 feet below that. The next scheme is No. 3—the Toolsee scheme. There is to be a masonry and cement dam there 35 feet high (explaining this on the chart).

Colonel TREVOR—What is it you propose to do to strengthen Dams 1 and 2 and the weir at Vehar?

Mr. AITKEN—Put a puddle trench at the foot of the outside of the slope of the present dam.

Colonel TREVOR—It would be quite possible, I think, if you object to a masonry dam, to put a second dam behind all these three, and raise them 10 or 20 feet—that is, if you intended to bring in extra gathering ground.

Mr. AITKEN—You would require to raise the waste weir also.

Colonel TREVOR—But could you not raise the dams?

Mr. AITKEN—Yes, you might do so, but then we should be dependent upon only one source of supply. It is open to that fatal objection, and if you increase the gathering ground you will want a second line of pipes.

Colonel TREVOR—If you put in a pumping engine near Bombay you would reduce the pressure along the line of pipe, and so get a larger supply.

Mr. AITKEN—If the pressure was reduced at which you deliver the water in Bombay, you might deliver 25 per cent. more from the Vehar main.

The CHAIRMAN—Suppose you put up a pumping engine in some locality in the island of Bombay itself, to deliver the water at Malabar Hill, Colaba, and the outlying districts, could not you then get much more water?

Mr. AITKEN—It is not Malabar Hill alone; it is Nowrojee Hill and up by the Jail and Mazagon. Those places are very insufficiently supplied now, but that is more because the pipes are not of sufficient size.

Colonel TREVOR—Suppose you had a pumping engine put somewhere near the Byculla Station?

Mr. AITKEN—The pressure at Malabar Hill now is not great; a sluice is wanting: as soon as they get that it should force the water up. You can't get water up to Malabar Hill unless you cut it off from the native town. Malabar Hill is 100 feet high.

Colonel TREVOR—For every gallon you give to Malabar Hill you shut off three gallons from the native town?

Mr. AITKEN—Yes.

The CHAIRMAN—But you could get rid of that by establishing a pumping engine?

Mr. AITKEN—Yes; and the only thing then would be Colaba.

Colonel TREVOR—You might have two sets of pipes, low pressure and high pressure.

Mr. AITKEN—These things, of course, are all to be got over, but the fatal objection to all these schemes is the dependence upon one reservoir. The supply is very deficient now. About three-quarters goes to waste, not absolutely, of course, for it goes into the drains and helps to clear away the filth of the town, absorbs the foul gases, and prevents silting up of the drains, and so does much work. I think you require more water for drainage purposes, if six gallons is required for each individual.

Colonel TREVOR—And in a town without drains the extra water is a nuisance, for the water does not pass off.

Mr. AITKEN—If there are drains they carry off the foul water, impregnated with gases; if not, it stagnates. A system of drainage that will drain the subsoil is necessary.

The CHAIRMAN—Do you think that anything could be done to supplement the Vehar supply by storing the monsoon supply on the Flats or anywhere else, and then pumping it?

Mr. AITKEN—No; I do not think it would pay. Of course you might run a bank round and across the arm of the sea at Coorla; in fact, many things may be proposed.

Colonel TREVOR—What do you expect would be the condition of the water at the end of the hot weather?

Mr. AITKEN—Very foul.

The CHAIRMAN—But if you had a covered reservoir?

Mr. AITKEN—A covered reservoir is very expensive. The proposed covered reservoir at Colaba of 4 acres, built under the most favourable circumstances, was estimated to cost 12 lakhs, and that only was to hold 12 million gallons.

Colonel TREVOR—So that a covered reservoir for the present daily consumption in Bombay would cost 8 lakhs?

Mr. AITKEN—Yes; under the most favourable circumstances it might perhaps be done a little cheaper, but still I think it is too expensive to be entertained: it would cost Rs. 80,000 or Rs. 90,000 per million gallons, which is an expenditure that I don't think is called for in Bombay. In fact, the reservoir at Vehar is no further from the city than the service reservoir of the Glasgow works, so it is practically the same.

Captain TULLOCH—That is to say, that to construct a covered reservoir to hold the daily consumption of Bombay would cost 8 lacs?

Mr. AITKEN—Yes. Then there is the Poway scheme—I don't know that there is much to be said about that; it is very simple and straightforward, and no difficulty attends it, and the dams are all very manageable and of easy height. We could have a very fine reservoir, but we are deficient in gathering ground, and I don't see how it could be increased by catch-water drains.

Colonel TREVOR—But you can increase it by the Toolsee scheme.

Mr. AITKEN—Yes, that comes to a very moderate sum, 35½ lacs.

The CHAIRMAN—Practically, the safety of the Poway reservoir would be the safety of the Vehar?

Mr. AITKEN—Yes.

The CHAIRMAN—Then you get no additional source of supply?

Mr. AITKEN—No.

Colonel KENDALL—In the evidence you gave to-day you stated that you preferred a steel main to a duct of masonry for bringing down water; is that more on financial or engineering grounds?

Mr. AITKEN—I have no special preference for a steel main instead of a masonry duct, but I prefer it to having a service reservoir and eternal pumping by engines of 1,300 or 1,400-horse power.

Colonel KENDALL—You prefer a steel main to a duct, together with a service reservoir and pumping; but that is your only objection; is that on financial or engineering grounds?

Mr. AITKEN—On both, as I have shown. The estimated cost of pumping and a covered duct, like the Glasgow, would be 1 crore and 80 lacs.

Colonel KENDALL—You have estimated for a covered duct the whole way?

Mr. AITKEN—Yes.

Colonel KENDALL—And you think that it would be necessary to have the duct covered?

Mr. AITKEN—Yes; for there is an enormous quantity of pack bullocks coming down that Ghaut with corn, and they would travel along the line the duct would take. There is another objection to an open duct, and that is, that it would soon get grown up with weeds, which would need cleaning out, so that the water would not be of the quality which should be supplied to a town.

The CHAIRMAN—But could not that be got rid of by careful filtration?

Mr. AITKEN—No; I don't think you can get rid of vegetable matter in solution by filtration; but I speak subject to correction by the medical gentlemen. In India the weeds grow to 8 feet or 9 feet long, but they don't grow so at home.

The CHAIRMAN—You would not mind an open duct passing through the rocky soil which you would have for a great part of the way?

Mr. AITKEN—I think open ducts are all objectionable; in fact I think they are all abandoned now.

Colonel KENDALL—I have been reading a description of Mr. Bateman's project for water supply to London, and he is in favour of an aqueduct through the thinly-peopled or unpopulated part of the country.

Mr. AITKEN—The duct at this place must either have a high wall or be covered in, for there is a vast quantity of bullocks and men always going up and coming down the Ghaut.

The CHAIRMAN—Supposing you brought down water from the neighbourhood of Shewla, as you think, could you supply any towns on the road—Tanna and so on? Do you think there would be a large demand at those places?

Mr. AITKEN—The Railway Company would want a good deal; it would save them pumping, and they would be the chief consumers. I don't think very much would be taken by the towns. The Railway Company is put to a considerable strait for water, and of Rs. 75,000 I calculate on getting from places along the line of water Rs. 25,000 will come from the towns and Rs. 50,000 from the Railway. There is one point upon which Mr. Ormiston was good enough to say that he thought I was mistaken—viz., as to the power to be got from the water in the reservoir. I don't think I am wrong, but I think Mr. Ormiston has rather hastily thrown it on one side. The first cost of the reservoir, with the necessary pipe and turbines, would be about 16½ lacs, whereas the first cost of the engines of 2,000-horse power would be about 16 lacs, so that the cost of the steam engines would really balance the first cost of the works. And you save the coals, which is a very great saving indeed. The calculations of the horse power to be obtained from turbines are taken from the Lowell experiments, where they used turbines for spinning cotton. And I think Mr. Ormiston spoke without having given the matter due consideration.

The Commission then adjourned till Saturday, April 3.

FIFTH DAY. SATURDAY. APRIL 3.

The following Commissioners were present—

ANDREW R. SCOBLE, Esquire, *Chairman.*
Colonel KENDALL, R.E. | Lieut.-Col. TREVOR, R.E. | Dr. HUNTER.
Dr. LYON, *Secretary.*

The Commission resumed at 2 o'clock on Saturday, in the Durbar Room, Town Hall.

MR. THOMAS BLANEY :—

By the CHAIRMAN—Mr. Blaney, you have had very considerable medical experience in Bombay, I believe?—A. Yes; I have been here a great number of years.

Q. And are well acquainted with the Native Town?—A. Yes; I have been all over it.

Q. What is your opinion as to the necessity of an increased water supply?—A. That we require an immediate increase, that it is an urgent matter, and is becoming more urgent with our daily, our yearly increasing population. That, I think, is quite indisputable.

Q. On what ground have you formed that opinion?—A. Personal observation leads me to believe that the largest proportion of this population limit themselves to a daily supply of two gallons of water per head. I cannot speak with great accuracy on that matter, but to the best of my belief two gallons per head of the population is the general quantity used. I can call to mind hundreds of houses in which I have been, and acquainted with the domestic habits of the people, and in which that is about the quantity, and perhaps the maximum I may say. Now I think, looking to the question from a sanitary point of view, that is vastly insufficient.

Q. Then to what do you ascribe the fact that only two gallons a head is the daily supply used?—A. There is the difficulty of getting it, there is the labour of lifting, and the distance people have to carry it, in many cases as much as a quarter of a mile. This is a serious loss of time; and then, with regard to the labouring people, this loss of time is not the only serious matter; after the day's labour we must suppose they are tired and would bring home as little water as possible.

Q. Then your objection would be rather as to the present insufficient distribution?—A. I don't think there is a sufficient quantity in Bombay, if we cast aside—as I think, as sanitarians, we are bound to do—the supply from tanks, which is tainted by percolations from sewers and other places, of which, I think, we can have abundant evidence by going round the town.

Q. When you say two gallons a day, I suppose you don't refer to the Vehar water only, but to water from all sources?—A. I refer to water from all sources for domestic purposes, and I would include in that the washing of the natives—you can't call their ablutions bathing.

Q. Do you think the Vehar water now supplied of good quality?—A. Very good compared with what we had for so many years, that is well known to all the natives. They admit it; even those who first had some prejudices against pipe water, as it is called, have had their prejudices quite removed so far as I know, and are quite at one with those who are advocating an additional water supply; they are quite at one with us in saying that it is excellent water. There may be occasional instances in which a man may send to Bholeshwur, Mahaluxmee, or some other favourite tank, but that cannot be for sanitary purposes. It must be owing to some superstition. I am speaking now of the intelligent proportion of the native population. I believe they are quite convinced of the superior quality of the Vehar water, and if they could get an increased supply, it would be generally considered a very desirable thing.

Q You are aware, Mr. Blaney, that the average daily supply through the main from the Vehar Lake is ten or twelve gallons per day per head of the population ?—A. I am, but I don't think that is any proof that that quantity is used or taken into the houses. It means simply that that is available.

Q. Do you think that ten or twelve gallons is a sufficient supply ?—A. Certainly not.

Q. What would you consider sufficient ?—A. That involves a question we are not considering at present—the drainage of the town.

Q. But apart from drainage, how much do you consider the quantity required for the ordinary uses of the people ?—A. Fifteen gallons.

Colonel KENDALL—But now that the people have twelve gallons per head per day coming through the mains, and have in addition all the water derived from the wells and tanks, and when, according to your opinion, they use only two gallons per head, including a considerable portion from these tanks and wells, why should you consider an increased supply from a distant source at all necessary ?—A. I cannot conceive a full supply of water being provided by this Municipality for these people unless an additional supply of tanks, dipping wells, or whatever they may be called, be provided in greater abundance than they are at present.

By the CHAIRMAN—That is what I wanted to come to. There is at present an available supply of ten or twelve gallons per head per day, taking the whole to be derived from the Vehar Lake. Of that you say only about two gallons is used by a large proportion of the population. What means would you suggest to bring home a larger supply to the people ?—A. I would have a larger number of dipping wells.

Q. Do you think dipping wells are good ?—A. I would have iron wells—large buckets they may be called, six or eight feet in diameter, and perhaps six or eight feet deep. No percolations could defile that water. There would be the trifling objection that a number of people would come with their own buckets, chatties, or pots. These vessels might not be perfectly clean ; but as the supply would be continually carried away and renewed, I should not anticipate much danger from that. I should, from a sanitary point of view, regard that as a tolerably wholesome and cleanly way of supplying the people.

Q. Do you think dipping wells are as good as stand pipes ?—A. The latter are liable to get out of order. I don't think that is exactly a question for me ; it is more of a mechanical matter, but I would say that forty people may get round a well of an evening, whereas only one can be supplied at a time from a pipe. For instance, on the back road towards the Brae, at Chinchpoogly, you will see a large number of people continually waiting for their turn to fill their chatties. I have seen women there in passing, and after spending three quarters or half an hour, I have seen the same people still waiting when I came back.

By Colonel TREVOR—That is at the stand pipes ?—A. Yes.

By the CHAIRMAN—In what parts of the town do you consider further dipping wells or stand pipes should be provided ?—A. Every part.

Q. As to the water that is derived from the tanks, of which we have heard, there are some 81 on the island. Do you consider the water from these tanks is injurious to health ?—A. I do.

Q. Especially, I suppose, from the larger tanks—Bholeshwur, Mahaluxmee, and Mombadavie ?—A. It depends upon the way they are used and upon the surrounding soil. I daresay in the most populous parts of the city they are extremely objectionable, as for instance in the Fort, where such a large number exist in private houses. I consider these exceedingly objectionable ; and then in the low-lying districts where we have no proper drainage, where of necessity we should expect water to contain organic impurities, they are very objectionable.

Q. With regard to the wells that are not supplied with Vehar water, do you know whether the water from these is used for drinking ?—A. I believe it is.

Q. Have you examined any of the water from these wells in the Fort or any of the other parts of the town ?—A. No ; I have not done so. Dr. Hewlett told me that it was the intention of the Health Department to make periodical analyses of the water from these wells, and I believe that, had that been done, a number of them would have been shut up owing to the very questionable character of their contents.

Q. What is your opinion as to the character of the water contained in some wells, as shown by the analyses which we have here of the water in thirteen different tanks and wells in Bombay ? (Handing analytical tables to Mr. Blaney.) For instance, Nos. 8 and 9 ; the one is a well at Breach Candy, and the other a well near Funnaswady ?—A. These are very bad.

Q. You might say poisonous, I suppose?—A. Unfit for human consumption, or for consumption by any animal.

Q. Then as to Nos. 12 and 13, two wells in houses in the Mombadavie Road?—A. They seem to be much the same.

Q. Equally pernicious?—A. Quite as much; there is so much impurity that a unit or two more or less in the analysis is of no consequence.

Q. Do you think it would be advisable to establish house connections in order to carry water into all the houses in the Native Town; or do you think that it would be more advisable to leave certain classes of the people to go and draw the water from such dipping wells as you speak of?—A. I think that tanks or dipping wells are more advisable for the lowest classes of the population.

Q. If the number of dipping wells were greatly increased, do you think a larger quantity of water would be drawn from them?—A. I am quite sure of that.

Q. Take the case of some of the lower orders: to what extent do you suppose they would draw water if they had a dipping well within fifty or a hundred yards of their houses?—A. They would bathe more frequently, they would wash their clothes more regularly, and especially so if provision were made for bathing. At present, people who take a chattie of water and wet the road while washing are taken up by the police and are punished for committing an offence under the Municipal Act, and if there were bathing accommodation under proper supervision, I am quite sure the people would bathe more frequently. It seems so natural, and it is the practice of the natives of this country to bathe every day if they can possibly manage it, that I am quite sure bathing is prevented by an insufficient supply of water in a great number of cases, and certainly clothes-washing is prevented.

Q. Would you have bathing places provided in the houses or on the streets?—A. Both would be required, I think. Little children would bathe with their mothers in the house, and for women and delicate sickly people we should require in-door bathing-rooms; but no doubt the adult males and boys would enjoy outside places, and outside bathing accommodation would be very desirable for these.

Q. Supposing you had these dipping wells, what quantity per day do you calculate a family of the poorer classes would take the trouble to fetch?—A. If it were near, I should think they would fetch five or six gallons per head.

By Colonel TREVOR—Is that the outside limit of what you say they would fetch?—A. Oh no, a great number would fetch much more.

Q. What is the average number of people in a family here, do you know?—A. I don't know. I think it is stated in Dr. Leith's census report.

By the CHAIRMAN—The poorer people do not live in separate families, but in groups of families?—A. Yes; and in large chawls. I think Dr. Lumsdaine estimates them at 400 in one chawl.

Dr. LUMSDAINE—850 persons.

Mr. BLANEY—Well, I am giving it very moderately.

By the CHAIRMAN—Then their washing and bathing would have to be done out of doors?—A. It would. They cannot bathe unless they go to the streets, for these places are so built that there is no bathing ground at all.

Q. How would you utilize a large supply of water in places of that kind?—A. It would be necessary to supply bathing-room accommodation.

By Colonel TREVOR—That is, you would have to alter the construction of the buildings?—A. Yes.

Q. It comes to this: if you give a large supply of water you have to alter and improve the character of the dwellings also?—A. I am under the impression that we are proceeding in that way.

Q. Is not that a slow operation—improving the character of the dwellings in the town?—(No answer.)

By the CHAIRMAN—But, as a matter of fact, large houses are being built for the poorer classes? Do these show any improvement on those built fifty years ago?—A. They are worse; I am very decided about that. And the effect is high rents.

Q. Then without a very stringent Building Act, do you see any probability of inducing landlords to build houses with due regard to sanitary arrangements?—A. I do not; and I believe public health must deteriorate.

By Colonel TREVOR—Then what would be the advantage of an increased supply of water under such circumstances?—A. I believe bathing would be increased even without better bathing accommodation, and at the risk of being taken up by the police. There are hundreds and thousands of such cases every day. The people are not all taken up every day; in fact, we would require a Russian army

to take up all offenders against the Act, and if there are a great many who go to bed at night and to their work in the morning without a bath, that is not so much owing to the tyranny of the Municipal Act as to the insufficiency of the water supply. At all events, it appears to me the duty of the Municipality to provide the water.

Q. That is to say, the Municipality must provide water for public bathing places?—A. And provide bathing places, too.

Q. Is not that a luxury?—A. Not in India; it is an essential to health.

Q. Do you think it essential to have a bath for every hut in Bombay?—A. It is essential, I believe, to have a bath in this country every day.

Q. And to have the water laid on?—A. To have it within reach—within a reasonable distance.

Q. What do you call a reasonable distance?—A. Well, say the length of a street. Fifty or a hundred yards should be the maximum distance that a family should have to go to fetch water.

Q. What quantity of water do you suppose they would fetch then?—A. That is purely speculative; five or six gallons, I should say.

Colonel TREVOR—You ought to think twelve gallons per head sufficient if the consumption under such circumstances does not exceed 5 or 6 gallons.

Mr. BLANEY—If it is within reach, that would be a very good supply. But yet I don't think it is sufficient. There is another view to take of the matter besides the questions as to what the people are doing now and what they may do. There are certain rules necessary for health which should not be deviated from; and according to these rules, I think a full supply means something like fifteen gallons per head in this country for domestic purposes.

Q. Have you any instances to bring forward in which there is such a supply in India?—A. People living on the banks of rivers have any quantity; but if they go down to the river they all use the same water for bathing and washing clothes. I must admit I don't know any town in India so far advanced in respect of a water supply as Bombay. We are certainly enjoying an inestimable blessing here.

Q. Would you take the Fort of Bombay as a fair example of the consumption of water were it laid on to every house?—A. I have not advocated the laying on of water in every house, even in the Fort. The number of people is so great in some of these places, that I cannot conceive a cock remaining workable for twenty-four hours.

Colonel TREVOR—What would you say to these instances of which I know? In Fort William, Calcutta, they have the water laid on to every barrack-room, to every house, and every street, and yet the consumption does not exceed ten gallons per head at the highest pressure. The water is free to every person who chooses to take it.

Mr. BLANEY—To the whole civil population?

Colonel TREVOR—There is no large civil population.

Mr. BLANEY—Well, for military officers and men. I should think there is a difference between a military and civil population.

Colonel TREVOR—Do you think the military the dirtier class of the two?

Mr. BLANEY—No, no; not in reference to cleanliness; but a civil population uses water for all sorts of purposes.

Colonel TREVOR—Do you get any good by using more water than is absolutely required? For instance, a European soldier washes every day. Do you think any good is to be got by using more water than he uses?

Mr. BLANEY—Well, I don't know exactly when we should say an individual has used absolutely enough water. The consumption for individual purposes must be greater in a family, or by an individual one day than another day.

Colonel TREVOR—Still is any good to be gained by inundating a place with water if it is not required?

Mr. BLANEY—Pumping it out of the town, do you mean?

Colonel TREVOR—Bringing into the town what is not required.

Mr. BLANEY—That is inseparable from the question of drainage. There is no doubt a city like Glasgow, with its supply, does waste a quantity of water.

Colonel TREVOR—What is your experience in India as to the healthiest stations? Would you say the dry or the moist?

Mr. BLANEY—I have no general experience of India.

Colonel TREVOR—You must have read the returns of military stations.

Mr. BLANEY—I am not prepared to answer as to the order in which the military stations of India are to be taken with regard to health.

Colonel TREVOR—Don't you know that Deesa and Aden rank high in point of health?

Mr. BLANEY—I do.

Colonel TREVOR—And what can that be due to?

Mr. BLANEY—I have seen Aden very bad, too.

Colonel TREVOR—Yes; but as a rule.

Dr. HUNTER—I would not place much reliance on these statistics from Aden. It used to be a common practice to send moribunds for change of air from Aden to Bombay.

The CHAIRMAN—To what do you attribute the health of Deesa?

Colonel TREVOR—To the dry climate. I will take Deesa as an example.

By the CHAIRMAN—Suppose you had this increased supply for those people who live crowded together in chawls and houses, how would you get rid of the waste water after using it, in the low-lying parts?—A. I should connect it with the drains.

Q. Do you think surface drains would be enough to carry off the waste water?—A. No; not in low districts. But that is more an engineering question.

By Dr. HUNTER—I don't know, Mr. Blaney, if you would advocate that there should be a bathing place in every house?—A. Not absolutely.

Q. But supposing they wished to have it?—A. No.

Q. But in many places at present there is only a large stone. Would you object to that?—A. At present the Municipal Act won't allow that, but I would not care though it were out of the house. I don't advocate that it should necessarily be in the houses of the very poor outside, even on a stone in the way many of the natives prefer to bathe. If there were proper drainage for the waste water there, I believe the consumption would be very large, and that would be a very great advantage.

Q. Then I understand you advocate bathing places properly constructed for natives?—A. Yes.

Q. Not that they are to be allowed to bathe on a stone opposite the door?—A. No.

By Colonel KENDALL—Do I gather that your recommendation for an increased supply of water would necessitate improved bathing arrangements and improved interior arrangements in the native houses, and also house connection with the drains and every house to let off the waste water?—A. I think so. That ought to be our eventual arrangement, but I am convinced of this, that we should have the water brought near the natives.

Q. I am not talking of that, but do you recommend an increased water supply before these arrangements are made?—A. Certainly.

Q. And what would be the effect of using all this water before any complete system of house drainage was entered into?—A. I think we are not quite understanding one another. I wish to say that for the present, whatever the Vehar supply may be, it should be placed within reach of all the population. And I should think it would be the general opinion that an increased supply beyond that from Vehar is necessary, as I suppose it will when the question of water supply is considered as a whole. This then will form a question the Municipality will have to deal with. It is a question of great sanitary importance, not only that a man shall drink pure and wholesome water, but that he be able to wash his clothes and have pure water for all sorts of necessary purposes.

Q. Now you have qualified your opinion, I think, by saying that the increased supply must be accompanied with a perfect system of house drainage and decent bathing arrangements in all native houses?—A. It is not so much a question within my province or on which I am able to speak practically; but I believe the distribution of Vehar water as at present carried out is totally defective. A friend of mine left Colaba a fortnight ago because he did not get a bath more than once a week, and he doubled his rent for a house, I believe, so as to get a better water pressure.

By Dr. HUNTER—You said 15 gallons a day would be a sufficient supply. Is that a personal supply?—A. Personal and domestic, for washing, bathing, and animals, and so on. I cannot estimate the water for drainage at present.

Q. But do you think 15 gallons sufficient for personal and domestic purposes, washing and cooking, and for domestic animals?—A. Yes.

Q. Have you thought of how much a common cow or ox could drink daily?—A. No, my business has led me to neglect even the horses and cows which I have myself.

Dr. HUNTER—It is calculated that a cow drinks about 8 gallons a day.

Mr. BLANEY—I should think so; a good milk buffalo requires 15 gallons.

Dr. HUNTER—But the bullocks you see on the streets here ?

Mr. BLANEY—Ten or twelve gallons. Well, that would leave three gallons for house purposes.

Dr. HUNTER—Then there are horses too. They are more numerous here, in proportion to the people, than in an European city.

Colonel TREVOR—We would get that out from the wheel tax ?

Mr. CRAWFORD—You would get the number of wheels, but not of buffaloes.

By Colonel TREVOR—Would not great economy be introduced with regard to water if you had both public bathing places and public washing places established ?—A. I don't think that would make any difference. After a number of persons have jumped into a tank, or trough or well, the water ought to be removed in pretty much the same way as when a person gets into a tub. Anything else would not be clean.

Q. What would be the result of a failure of the Vehar water supply for one year ?—A. Fatal. We would have to go and encamp under the Ghauts.

Q. Would it be worse than it used to be in Bombay ?—A. Much worse. I have played at cricket in the Rampart trench when it was dry, and I can remember poor natives coming and digging 8 or 10 feet and taking up the mud and straining it through a dirty cloth and taking it to their houses —and that was the time when the people died by hundreds of cholera. I am speaking of thirty years ago.

Mr. BLANEY—With reference to the last question, I think it is very plain that in a city dependent on a single reservoir or main—especially on a reservoir having three dams which may give way at any moment—a failure would be very disastrous to the health of the city, particularly in a place like Bombay.

By the CHAIRMAN—Are there any other observations that you wish to offer on this question of water supply ?—A. With reference to Mr. Aitken's two schemes, which come on for immediate observation and which are now before the public—the Canery scheme and the Shewla scheme; I think as to the Canery scheme, considering the whole question of water supply in Bombay in its amplitude, that that scheme would only be a patch upon the Vehar supply, and ultimately, false economy. The Shewla scheme is well enough, if I might be permitted to say in reference to an uncovered steel main coming in on masonry pillars for about 56 miles, that the water which left Shewla at seven o'clock A. M., would come into Bombay in the afternoon in a state for boiling an egg, warming a child's conjee, or giving a rheumatic patient a hot bath ; and such water would be prophylactic and therapeutic.

Q. Then you do not think that the idea of a steel main is a practicable one ?—A. There seem to be a great number of objections to it.

Q. As a ratepayer, what do you think of the cost of the Shewla scheme ?—A. A good sound water supply in the hands of a good careful Municipality might possibly be preferable, and the very first consideration seems to me to be, to have the sanitary wants of the city properly supplied; and if any better scheme offered, and it turned out that thirty gallons per head were necessary for the wants of the city, it might be considered whether we might finally adopt the Shewla scheme, with perhaps some modifications of Mr. Aitken's proposal for a large and expensive steel main. I am assured by some people in Bombay that the rivetted barrel of a main in steel would be a very difficult matter to repair; and we might expect many leakages that might cut off the supply for a long time from Bombay. The cost of the scheme is fatal to its adoption, as I take it. If you pay perhaps two millions sterling for an additional water supply, although I grant you we might make some returns from it, if it was well and carefully managed and kept in the hands of the Municipality, yet it seems a very large sum to expend just now. About the 300 feet of pressure, which Mr. Aitken says will only come to 80 feet when the water comes into Bombay—I am not able to say whether that number of feet is right or not; but one continuous pipe from the reservoir to the distribution pipes might be very advantageously applied for the purposes of power : for instance, on our bunders and in our railway sheds, and so on. But I do not see what other uses it can be put to. I can conceive such a main with a water supply derived from Shewla broken by a service reservoir midway. If we could keep the hill course and secure a service reservoir at a height of 150 feet or so, and with a surface reservoir to contain one or two days' supply, we should not want such a strong main. Then we only want the main so strong on account of its pressure. This is a very expensive main. Its price may be £20 per ton or £30 per ton, but I have not seen any person who has had any experience of steel mains four and a half feet in diameter, and I think the item of

expense is very highly objectionable. I do not know what the expense might be of a cast iron main; but supposing we had a reservoir at Shewla, and a service reservoir and at mid-elevation, following the hill course, we might have the water in an open aqueduct. I think it was Captain Ducat who gave an estimate for that work at Rs. 20,000 or Rs. 30,000 per mile, which is vastly less than the cost of a steel main; and in that part of the country, if there was no very large population, an open aqueduct, although objectionable in a sanitary point of view, might be constructed immediately, and there would be a saving of so much in the main, that we should bring it at once to a practicable and known dimension. We know nothing of a 56 miles main pipe at 300 feet pressure. In hydraulics, I believe it is almost unknown. I believe the strength of Mr. Aitken's main is alike all through. Now the pressure at the main reservoir, when the dam was full, would be nothing, while the pressure at the sea level at Callian, or thereabouts, would be four times as great. Yet the steel main is calculated to have an equal pressure all through, and one of two things must happen: either that the main at the sea level is deficient in strength, or that it is too strong at the reservoir, and that we must pay so much the more for it. If there was a large permanent population between Shewla and the service reservoir I propose, the population would gather near it and defile it, and so the water would become impure.

Q. That might be got over by filtration?—A. We could not get to it. We should be such a distance from it that we could not say what might be thrown into it either by mischievous persons, or accidentally, or from bad habits. Then if we brought the water to a practicable pressure from this service reservoir of which I have been speaking, an iron main would do, although perhaps its diameter would have to be increased a little. At all events the scheme would be quite manageable. I think the Glasgow main has a diameter of 5 or 6 feet; an iron pipe is quite practicable there; but the cost of carriage would of course be a question. Now there is something said in Mr. Aitken's report about cast iron pipes being cracked, and that one inch and three quarters would be the thickness which we should require for the Shewla scheme if it was carried out by means of an iron main. But I hear from people who are practically acquainted with iron, that we should find that even if a man wielded a 56 lb. hammer, he would find great difficulty in cracking one of these pipes if he worked at it from morning till night.

Q. Do you think, with a largely increased water supply, there would be much demand for the water for irrigation and garden purposes in Bombay?—A. I am not prepared to say.

Q. Supposing there was to be a large demand for water for such purposes, do you think it would conduce to the general health of the city?—A. Yes, I think so. I believe it is a matter of history, that wherever a full supply of pure water has been brought in to a place where a scarcity of water existed before, the health of a city has always improved.

By Colonel KENDALL—You say you do not consider that irrigation near the dwellings of Europeans in this country is prejudicial to health?—A. I addressed the Municipal Commissioner on one occasion on the subject of market gardeners and their operations in the compounds of our dwellings—the dwellings of those of us who are unfortunate enough to share a property with market gardeners. But if these agricultural operations were properly conducted, and the city properly drained of all surface or sub-soil waters, I do not think they would be dangerous to health.

Q. With these provisoes?—A. Yes.

By Colonel TREVOR—And you think that as it is it would be dangerous?—A. Oh, yes; these people go on now bringing in tons of fish for manure. Yesterday I was called upon to treat a whole family, who, from some stinking fish having been brought in for agricultural purposes, had all been attacked with colic and were quite ill all night, the husband, wife and child. Under such agricultural operations of course health would suffer. In my own case, I may say, that I have an immense large compound, which I was sharing with a market gardener, and what with bullocks, manure, and other abominations, I was very glad to propose to my landlord to take over the whole of the ground and pay a larger sum of money for my bungalow, rather than permit what was going on to continue.

By the CHAIRMAN—Then under the present system would you consider an extension of market gardening conducive to health?—A. So small is the space for building and so defective the ventilation of the city, that I think there is a greater necessity for providing building accommodation and for ventilation wherever we can ventilate, than considering the question of market gardens. If we cannot get gardens in the Fort, we can get them at Byculla, and if not at Byculla, we can go further north, and so the supply will be kept up. There is no danger on that point, whereas there is great danger from overcrowding and want of ventilation, which prevail fearfully, whilst the ventilation is very bad.

By Colonel TREVOR—Do you consider overcrowding now the great evil in Bombay ?

WITNESS—Sanitary evil ?

By Colonel TREVOR—Yes ?

WITNESS—I should not like to answer you in that way, but it is a very great evil.

Q. Even greater than the want of water ?—A. That is a relative question to which I could give only a relative answer. I could not answer it positively ; but they are both very great evils.

Q. But you must judge of things relatively ; you cannot do things all at once ?—A. I must admit my utter inability to speak very decidedly upon these points.

Q. But these are points which have to be determined whenever you have to discuss questions of this kind ?—A. It would only be an opinion after all, and perhaps an opinion on a matter to which I have not given any special attention—an opinion drawn out on the spur of the moment. I may take this opportunity to say in connection with the water supply, that it is a question which I have never written on, or ever studied, but as the Commission asked me to come and say what I had to state, I was very glad, as a citizen of Bombay—as I hope I always have been glad—to come forward and give the impressions I hold on the subject.

The CHAIRMAN—We are very much obliged to you, Mr. Blaney, for the expression of your opinion.

MR. A. T. CRAWFORD, *Municipal Commissioner* :—

Mr. CRAWFORD—I was asked by the Commission to prepare this statement, showing the average daily consumption of water in the hospitals, mills, and factories in Bombay.

Mr. Crawford handed in the following statement :—

No.	Names and Description.	Average Daily Consumption as shown by Meters.
		Gallons.
1	Hospitals, Schools, &c., (free supply)	18,275
2	Mills, Factories, &c.....	328,890
3	Meter connections for irrigation (55 in number)	42,250
4	Shipping in the Harbour	17,330

(Signed) A. T. CRAWFORD,
Municipal Commissioner for the City of Bombay.

Bombay, 3rd April, 1869.

These (he added) should be taken as the minimum rates, as they refer to the monsoon months, during which time we find there is less water running through the meters.

By Colonel TREVOR—Do you know the proportion of houses with meters as compared with the houses which have not meters ?—A. There is a very small number with meters. There are many houses to which you cannot deliver water through the meter, because you have not sufficient pressure. I want to show as a matter of fact that the Vehar water supply is insufficient, and I propose to put in the files which we have in our office of complaints as to the insufficient supply of water to persons who have already got house connections. (Handed in file.) These complaints were comparatively few in 1866 and 1867. In 1867 they were only 28 ; but in 1868, owing to the increase of the connections, and the spread of the area over which the water was distributed, the number ran up to 86 ; and in this year there have already been 12, included in which are 8 general petitions from whole districts, pointing out that in these districts the whole water supply is insufficient, and that the water is only delivered from the main in driblets, and that consequently the petitioners do not get a sufficient water supply. As to there not being a sufficient supply, I would ask any one at all acquainted with the native town to drive through it in the early morning when people take water for their use, and to observe the amentable condition to which the people are reduced to obtain water for their daily supply. To multiply the number of dipping wells, where there is not a greater pressure, would be simply aggravating the evil, for there would be more sources from which the same quantity would be drawn, and there would be no advantage whatever gained.

Q. Would not it have the tendency to economise the water ?—A. What, increasing the dipping wells ?

Q. Yes, decreasing the house connections?—A. To increase the dipping wells would be the greatest mistake possible.

Q. Then you would like more private services?—A. No, I would have fountains in preference.

Q. Is not that more wasteful?—A. No.

Q. Does not everything which creates a difficulty in getting water tend to economy?—A. But there is another element to be considered—the desirability of supplying the pure water. Dipping wells cannot, under our best system of filtration, be kept perfectly clean. We are all unanimous upon that point. You (Colonel Trevor) seem to want to economise the use of Vehar water by enhancing the difficulties in obtaining it.

By the CHAIRMAN—Then you do not agree with Mr. Blaney that it would be advisable to increase the number of dipping wells?—A. No, certainly not; if the supply is to be increased, it should be by the increase of a certain number of stand-pipes or pumps.

Q. But stand pipes are unsatisfactory in their working?—A. Yes, they are all more or less liable to get out of order. But that is not the kind of thing I would have at all. I would have no machinery at all in the stand-pipe or fountain. The water should just rush out so as to allow the people to be able to fill their buckets direct from the mains as it were. Designs for this were got out about a year ago. We have several iron dipping wells such as Mr. Blaney advocated, and they are just the same as any other dipping wells. The impurities which get into the dipping wells come from the impurities in the utensils used by the people, and from persons standing near the wells when they wash their dirty clothes, &c.

Q. Then in order to bring the water supply home to the poorer classes, in addition to the dipping wells and fountains you would have to supply washing and bathing places?—A. Yes, one of the greatest wants in Bombay is that of washing and bathing places.

By Colonel TREVOR—Would not that have a tendency to economise the water?—A. I should think not, but it would have a great sanitary effect. I think a great deal more water would be used.

Q. Would not salt water do for the purpose?—A. No; the natives wash their clothes and their bodies at the same time; they could not wash their clothes in salt water. It is the habit of the people of the country to wash in this way. Salt water destroys clothes.

By the CHAIRMAN—Do you think if you established public bathing places, that the natives would resort to them?—A. Yes, largely. It is only after working hours, after the unfortunate poor leave the mills or other places of work, that they can bathe. A man goes to his little back yard where you see him and his children. He has a small chattie of water, and is trying to get the dirt off his skin. There is not a single artizan in Bombay who would not be immensely pleased to get bathing houses established.

Q. It would not be an expensive thing at all?—A. I do not think it would be expensive, but it would compel us to have more fresh water.

Q. Then you think salt water would not do?—A. No, certainly not. In the first place, I think I am right in saying that the habitual use of salt water induces skin diseases. Is not that so, Dr. Hunter? and, in the second place, salt water rots clothes.

Dr. HUNTER—Yes. In this country the rapid drying of the salt water irritates the skin. You ought always to have fresh water to use after salt water bathing.

Mr. CRAWFORD—If you bathe in the sea much in this country, after you have come out and dry yourself, you have a sticky feeling, and are only too glad to wash yourself in fresh water immediately after. I have noticed myself—and I have been a great deal on the Coast—that skin disease is more common among the population who habitually use sea water for bathing purposes, and that they themselves attribute such diseases as common itch, and so forth, in a great measure to the habitual use of sea water for the purposes of washing.

By the CHAIRMAN—Do you think it would be safe, in a sanitary point of view, to have bathing places in the houses of the poor, as such dwellings are at present constructed?—A. No. I should be entirely opposed to any service pipes at all being introduced into the poorer classes of dwellings, as there is more water wasted in the poorer classes of houses where there are connections than in any other place. The demand on the private connections of the poorer houses is not only for those who occupy the houses, but every man who passes by goes in and turns on the tap for his own purpose. The demand for water amongst the poorer people is very much greater than we can supply to them.

By Colonel TREVOR—But a great deal of that might be remedied by having cisterns and limiting the supply every day.

Mr. CRAWFORD—Where would you put the cisterns ?

Colonel TREVOR—Attach them to the houses.

Mr. CRAWFORD—Would you have the cistern on the ground floor or above ?

Colonel TREVOR—Above, if it could be done ; but if not, on the ground floor.

Mr. CRAWFORD—That would involve the re-construction of all the native houses in Bombay. You could put the cistern on the ground floor, but it would soon become a private dipping well of the very worst class; and the cisterns would become altogether neglected. We should have no supervision over them, and in a very short time they would be dirtier than the dirtiest dipping wells now are. There would be difficulty in compelling the people to purchase cisterns, which would be saddling them with a very heavy cost, which might be expended to much greater advantage upon a new water supply. Of course the Municipality could not be expected to supply each house with a cistern.

By the CHAIRMAN—Do you think the poorer classes should be limited to the public sources of supply ?—A. Certainly, in the poorest quarters of the city.

Q. And do not you see any way, with the present supply from Vehar, of bringing the water more home to the poorer classes in Bombay without any addition to the present supply ?—A. There might be more dipping wells and fountains in certain districts, but the town could never be supplied sufficiently from the existing source of supply, simply because there is not sufficient pressure from the lake. We might lay another main from the lake now, but the only effect would be to draw off all the water in one season, and probably that would be an enormous risk, for the variation in the fall of rain upon the Ghauts is so great.

By Colonel TREVOR—Do you not think something might be done to economise the present supply ?

Mr. CRAWFORD—In what way ?

Colonel TREVOR—If you utilized it more. If there are complaints of deficiency of water, could we not economise what we have ?—A. The only thing that could be done, is to water the roads with salt water, and I very much question if that would not be saddling the people with a much greater burden in the machinery and piping for such a system than the cost of the increased water supply. I mean to say also that the people would appreciate very much more the consumption of this three per cent. of the day's supply in watering the roads than having it distributed over all the population of 800,000, as available for domestic uses.

Q. Do you think something could be done by making a large number of people dependent upon public sources of supply ?—A. It might be possible, but it would be regarded as very arbitrary, and we could not do it without additional sources.

Q. But the original intention of the Vehar Water Works was only to supply water from public sources ?—A. It is possible that it may have been so, but it was immediately departed from, for when I took charge of the Municipality I found all the rules for the service of water were based upon the system of private service. If people ask for water we cannot refuse them.

Colonel TREVOR—I did not know that there was any such law binding upon the Municipality.

Mr. CRAWFORD—Oh, yes, if we can supply water, and a man chooses to apply for it, we cannot refuse to supply it.

Q. But is not the supply in Bombay amply sufficient if it was delivered in public cisterns ?—A. In a country like India I think that would be absurd, and the supply is quite insufficient.

Q. But have you anything to go upon in support of that proposition ?—A. I base my opinion upon what was stated in reference to the supply of large towns at home. And I know from my experience of this country, and also from my experience of native habits, that they require even a larger supply of water than people in Europe, and that on account of the climate here a large supply is required. I do not think anything of the figures you gave Dr. Blaney, as to the military quarters at Calcutta. I do not think that there is any analogy whatever between the two cases.

Q. You think the consumption would be less in barracks than in the dwellings of people living in their own homes ?—A. Yes. These European soldiers who have been spoken of as being supplied with eleven gallons of water per head, are all kept under strict discipline, and most certainly they would not be permitted to waste the water or throw it about, and that I think is a very important element in the question. And then these Europeans have their clothes washed at a distance, and brought home to them after they have been washed. Now a great deal of the water supplied to the houses in Bombay is used by the poor people for washing their own clothes. Generally, the only clothes a poor unfortunate creature has are those he stands up in, which are washed every day of his

life; whereas the soldiers quartered at Fort William have their clothes washed for them at a distance, and have their cooking done in a separate building from the one occupied by themselves. And, again, the 10 or 11 gallons you speak of as supplied to the barracks does not include the water drunk by horned cattle and horses.

Colonel TREVOR—But in the Fort?

Mr. CRAWFORD—The Fort in Bombay does not exist now. The washing is a very important element. The discipline among the soldiers would prevent their throwing the water about, and spilling it and wasting it in the hundred ways in which natives would, without discipline.

Q. In your opinion, military discipline has a stronger effect in inducing economy than the carrying of water upon women's heads from a well half a mile off. If you were to carry in all your water from the public streets, half a mile off, it would be a greater preventive to waste than if water was drawn from a tap close by?—A. I do not think so. You have not hit the question. As to the water being carried half a mile, there are generally large numbers of members in a native family. The water is not fetched all at once, but people are going for it all day long; sometimes it is the little boy who goes for it, sometimes the little girl, and so on.

Q. Then you are of opinion that there is more than ten gallons brought into a house, even upon women's heads?—A. I do not say that they take that quantity into the houses, and, whatever it may be, it is exclusive of water drunk by animals of all sorts.

Q. Well, how much do you think is used?—A. I really cannot say. It is impossible to say how much is used in every house. Undoubtedly a great deal is used; that is unquestionable.

Q. Are there not a great number of wells in private houses?—A. Yes.

Q. And do not the people use the water from these wells for washing purposes?—A. Yes.

Q. And is not that just as efficient for washing purposes as other water?—A. I should suppose not; if that had been the case it would have been unnecessary to construct the very large public clothes-washing establishment upon the Esplanade which is fed by Vehar water.

Q. But still, that washing could have been done with the water of the town?—A. No, it could not.

Colonel TREVOR—But it used to be got before the Vehar water was brought here.

By the CHAIRMAN—Is not washing clothes in wells within houses most injurious to health?—A. Most unquestionably. There ought to be large bathing and washing places in various parts of the town—such as the one at Dhobie Talao.

Q. As to these private wells; have you had any experience of them. Have you seen a great, many of them?—A. I know districts in which many of them are situated, and of which the water has been analysed.

Q. Do you know in what manner these wells are used; is the water used for drinking?—A. Yes, in almost every one of them.

Q. And for bathing also?—A. Yes. A man stands outside, fills up his chattie, and bathes and washes himself there, and part of the muddy and dirty water trickles down into the well. And cattle go and drink there. Altogether, these wells are exceedingly fatal.

Q. And the people wash their clothes on the stones surrounding the well?—A. Yes.

Q. And I believe a great many of these wells have privies and cesspools in the immediate neighbourhood?—A. Yes. For the matter of that, in certain districts the whole of the compounds are mere cesspools, covered with night soil.

Q. Of course, in the natural course of things, the water from these privies and cesspools would sink through into the wells?—A. Unquestionably; in the analyses you can trace the cholera districts as plainly as possible.

Q. Since you have been Municipal Commissioner, have you ever known a single instance of an inhabitant of Bombay taking any steps to clean out his private well?—A. I cannot say that I have.

Q. Do you know whether people take any steps to clean out these wells, or are the wells just left in their natural condition?—A. I have heard of a case in the Fort, in connection with a fire which occurred when the water was said to have become foul, and some people in that case went to some expense to clean out the wells; but as to any periodical cleaning of the wells, the thing is never heard of now, though it was a matter of necessity years ago.

Q. That was the case which Dr. Eduljee Nusserwanjee referred to?—A. It was here in the Fort where there was a large fire. I think it was in a place called Gunbow Lane.

Q. Have you ever known of any cases of persons who have gone down into these wells being suffocated?—A. No, I cannot say that I have. The Coroner will probably know that.

Dr. HUNTER (to Dr. Lumsdaine)—Have you ever known of such cases, Dr. Lumsdaine?

Dr. LUMSDAINE—Yes; there have been seven deaths registered from that cause; not since I commenced to act, but before.

Dr. HUNTER—I see it is stated in Mr. Bateman's Report on the water supply of London, that "when the Loch Katrine water was introduced into Glasgow, it was estimated, at the most careful computation, that the saving which resulted in domestic establishments was equal to the whole rate paid for the water supply, or £36,000 a year, in a population of 400,000." In the article of soap alone, they saved five-eighths of all that had been previously used.

Colonel TREVOR—Have you heard of any difference between Vehar water and well water?

Mr. CRAWFORD—There is no comparison between the two. Vehar water is pure; well or tank water impure.

Dr. HUNTER—There is no doubt that Vehar water is very much better for washing clothes than the water which was used before.

By the CHAIRMAN—Then as to the public wells and tanks, Mr. Crawford, I suppose you know all the large public tanks very well?—A. Yes, they are just so many cesspools.

Q. Particularly Bholeshwur, Mombadavie, and Walkeshwur. They are all very much resorted to for bathing by devotees of all kinds?—A. Yes. Walkeshwur water is also very much used for drinking. If you go there in the morning you will see people drawing water from the tank, and straining it through their clothes and putting it into their lotahs. But that is more on account of superstition, for the water is supposed to come from the Ganges. Then with respect to the Bholeshwur tank, the bottom of it is about 12 or 15 feet below a sewer, the water from which finds its way into the tank; being badly constructed, the chunam admits the water through. We cleaned out the tank and cemented the bottom some time since, but now it is as bad as ever. In Mombadavie tank the water is about the colour and consistency of pea soup.

Q. There is a great deal of washing done on the margins of these tanks, as well as bathing?—A. Yes.

Q. In point of fact, I believe during the fine weather a large number of people live upon the borders of these tanks and sleep there?—A. Yes.

Q. Is there no provision made near these tanks, in the way of privies and so forth, for those people who live in the open areas about them?—A. There are private privies in Mombadavie; but there is no space for public privies at Walkeshwur, but some are about to be erected on the sea shore.

Q. What provision is made for cleaning the water of these tanks?—A. None whatever. Last year we proceeded against the trustees of the Bholeshwur Tank, and we got a decree against them. We are now suing the trustees of the Mombadavie Tank. We have sent notice to the trustees of that tank, to have it pumped out and cleaned.

Q. Did you succeed in getting an order requiring the trustees of the Bholeshwur tank to pay for having the tank cleaned out?—A. Yes, for cleaning it. But it was essential that the bottom should be cemented. The law is defective on the point, and the Court decided that we had no authority to cement the bottom. The Court made an order requiring us to pay for the cementing, and the trustees for cleansing the tank. But no matter how often these tanks are cleaned, the water will never be fit for drinking.

Q. Have you power, under the Municipal Act, to close up private wells which contain impure water?—A. No, we have no power whatever to do so. We attempted to close the Babboola tank twice last year.

Q. The water in these tanks is merely renewed from the rainfall, I believe?—A. That is all. Some of them are fouled by the surface drainage, which of course carries down all manner of impurities, especially after the first fall of the monsoon. Speaking of these complaints of an insufficient supply, although they are sufficiently formidable, they do not represent a tithe of the verbal complaints made to our officers every day.

By Colonel KENDALL—Do I understand you to say that you could not run more water through the Vehar pipes than what passes through them now?—A. No, not through the main.

Q. But I mean to say that the supply of the lake would not afford a larger supply than passes through the present main?—A. Not without another main.

By Colonel TREVOR—But would not the lake afford an additional supply if it could be brought through the main?—A. Only by laying down a larger main. The present main does its duty fully.

By Colonel KENDALL—What objection is there to this intermittent supply?—A. It is rather serious. A man when he wants water cannot get it. I can imagine no greater objection.

Colonel KENDALL—But that is the case in many parts of London and in many towns in Europe.

Mr. CRAWFORD—But it is a state of things which should not exist if it can be avoided, and it is a state of things they are trying to get rid of in London and in every civilized town in the world.

By Colonel KENDALL—I do not think that there is any continuous supply in London?—A. In the city of London they are now seeking to obtain a continuous supply.

Q. But at all events they have not got it yet?—A. No, but they admit it to be an essential. I hope there can be no doubt that all houses ought to be supplied, or at all events the best classes of houses. We have only 7,000 connections, and there are 22,000 houses; and in such a state of affairs I cannot conceive that any person would call the water supply sufficient. Every other person has as good a right to have the water in his house as these 7,000 householders, but at present we cannot supply them, and they know it, and do not ask us.

Q. Would the returns at all afford a large outlay for this additional pumping in order to supply the high service at Malabar Hill?—A. Malabar Hill would pay over and over again for pumping. We had a scheme for supplying Malabar Hill. We were to fill a cistern at the quarries near Walkeshwur Road and pump up the water by Mr. Justice Westropp's house, and thence distribute it all over the hill. The great difficulty was that we could not get the service pipes paid for. The landlords ought to pay for them, but they won't do so.

By Colonel TREVOR—That is the hindrance?—A. Yes.

Q. Not the want of water?—A. Of course it would be so much drawn from the native town at night. I consider the question of supply to Malabar Hill a very secondary one.

Q. Would it not be tantamount to giving the Vehar supply to all parts of the town at certain hours, instead of letting one portion have it always?—A. No. At night some districts have no water at all.

Q. How do you reconcile that with this table, showing that there is 139 feet pressure at Freelands?—A. Freelands is not in the native town, but outside of it and above it, and is close to the main. I should think it probable there would be that pressure in order to distribute the water to Colaba at night.

Colonel TREVOR—But still if you have a pressure of 139 feet at one time, and 60 at another time of day—that implies a great reduction of the supply during part of the night.

Mr. CRAWFORD—A great reduction of the demand; for people of course cannot go for water at all times of the day.

Colonel TREVOR—A great reduction of the supply as well as the demand—they are equivalent terms.

Mr. CRAWFORD—Possibly there is some engineering question. I speak only to fact. Possibly Mr. Aitken or the turn-cocks, who are better acquainted with these matters, will be better able to tell you. But the fact remains, that we cannot give a continuous supply to more than 7,000 houses out of 22,000.

Colonel KENDALL—You have stated just now that the supply is not given to Malabar Hill because the landlords will not pay the charge for the pipes.

Mr. CRAWFORD—That is one of the delays, but when we have got the native portion of the town properly supplied, I will turn my attention to other quarters.

Dr. HUNTER—I understand that it was stated in the early part of the evidence—I don't know whether it was by you—that there was not enough water in Vehar Lake to supply all the inhabitants of Bombay. Suppose there was another main, would there be enough water in Vehar to supply the two mains?

Mr. CRAWFORD—Oh, yes, you could use both mains; but you would run a serious risk of the lake not filling next year; you must always keep a year's supply. Of course, by adding one, two, or three mains, you might increase the supply, but you would also run the lake dry.

Dr. HUNTER—Then the supply is not sufficient for the community?

Mr. CRAWFORD—Precisely.

The CHAIRMAN—Your opinion is that you could not safely draw more water from the lake than is taken at present.

Mr. CRAWFORD—Yes, and that is not my opinion only; it was decided by a Government Commission.

The CHAIRMAN—As to ways and means in connection with this water supply, what is the present debt of the Municipality to Government in respect of the Vehar Water Works?

Mr. CRAWFORD—About 37 lakhs. I can, of course, give you figures—annas and pies.

The CHAIRMAN—Is the contribution of Rs. 1,75,000 paid regularly to Government?

Mr. CRAWFORD—Oh, yes. Government are very careful to deduct that in the first instance from any contribution.

The CHAIRMAN—Can you tell us how long it will take to clear off that debt from the Municipality?

Mr. CRAWFORD—About sixty years.

By Colonel TREVOR—But after paying the contribution and all other expenses, you have a clear revenue of one lakh?—A. The total revenue is as nearly as possible four lakhs. There is a payment of Rs. 1,75,000 to Government; one lakh for maintenance, and Rs. 1,25,000 of profit.

Q. That is the actual profit the Municipality has gained by the construction of the Vehar Water Works?—A. Yes.

Q. And therefore the Municipality is no loser?—A. No, no.

Q. And therefore you have no grievance against Government?—A. I did not announce any proposition of a grievance against Government. I deny that we have any grievance except with regard to the excessive expenditure on the works over the Government estimate.

Q. Do you think that the work cost too much?—A. Not being an engineer, I can't tell; but there is the fact that it cost upwards of 100 per cent. in excess of the estimate. I feel sure that if the work had to be constructed now, it would cost as much as then on account of the difference in the rates of labour; but that is not the point.

Colonel TREVOR—Yes, the rate for labour is higher now.

The CHAIRMAN—Having regard to the revenue of the Municipality, with the exception of Vehar, what other sources would you fall back upon for the purpose of paying for the construction of the works?

Mr. CRAWFORD—If an additional supply of water were brought in, I would have an entire revision of the system of water supply. The present system is altogether fallacious. For instance, we see that a large number of the European residents in Bombay pay nothing for the Vehar water. Now that is not right. There is an immense number of people who are able to pay for water, and have no right to demand it gratis from the Municipality, who draw from the public dipping wells gratis. The remedy is to have a general water rate and a special water rate lighter than the present for domestic purposes.

By Colonel TREVOR—How would that act?—A. It would equalise the present rating, which is simply unfair, and makes 7,000 odd properties pay for the water supply of Bombay, Government instalment, and all other expenses.

Q. Is it not optional on their part at present?—A. Yes.

Q. And they would not pay it if they did not find it to their advantage?—A. Where it is a question of life and death, of course they will pay rather than not get the water.

Colonel TREVOR—But is it a question of life and death to the 7,000 more than to the others?

Mr. CRAWFORD—I have heard that argument used before, and it is nonsense.

Colonel TREVOR—When I had Vehar water, I paid Rs. 7 a month for it; but now that I have not got Vehar water, I pay Rs. 15; so that to equalize the rate you propose to tax still more the man who does not get water, but pays twice as much as if he had it laid on to his premises.

Mr. CRAWFORD—But to whom do you pay the Rs. 15

Colonel TREVOR—To the bheestie.

Mr. CRAWFORD—You pay him for carrying the water. The fact still remains that the cost of the works is being paid by these 7,000 people.

Colonel TREVOR—Who absorb how much?—A. About three-eighths, I think.

Colonel TREVOR—I would call the Vehar water a greater boon to those who have it laid on than to those who have still to fetch it from wells.

Mr. CRAWFORD—That is a matter of opinion.

By the CHAIRMAN—Supposing you were to establish a general water rate, on what basis would you assess it?—A. On the same system as the house rate. I would call it the "water extension rate," say at 1 or 2 per cent. I believe it would be cheerfully paid.

Q. And you calculate that a 1 per cent. water rate of that description would give Rs. 1,32,000?—A. Yes. A lakh and a quarter, to a lakh and 35,000.

Q. The surplus revenue of Vehar and a cess at 1 per cent. would give you about 2½ lakhs?—A. Government would lend us the money at the same rate that they are now lending it to Calcutta for the same purpose. 1 per cent. would be a very low rate to secure a continuous supply of good water, and people would, I believe, willingly pay 2 per cent. I have heard leading men among the natives speak of 5 per cent.

By Colonel TREVOR—But did they mean the 5 per cent. to be in addition to the present water rate?—A. Yes, a special extension rate.

Q. And that would make 10 per cent. on some houses?—A. No. The water rate is very small—5 per cent. on the first 100, and a reduction on every Rs. 100 rental afterwards.

Q. And you call that a light water rate in the pound?—A. No, no; I am saying it is not light. I advocate 1 per cent. I am speaking of a native gentleman who said 5 per cent.

Colonel TREVOR—I suspect he meant 5, not 10, altogether.

By the CHAIRMAN—What is the total value for assessment in Bombay now?—A. About a million and a half.

Q. And how many houses?—A. About 23,000 houses.

Q. And do you know how many landlords own those houses?—A. No; it is impossible to ascertain that, with the existing state of the law. It unfortunately happens that nobody is bound to register the transference of property; some properties are registered in the names of people who have been dead for years and years.

Q. But are not they registered in the Registrar General's Office.—A. Yes; we could have access to them there I daresay, so far as present transfers are concerned; but as regards the Fort there is no remedy.

Q. Would you propose to levy an annual water rate in addition to the present system, or in substitution of it?—A. I would alter the whole system of water rates. I would have a general rate, and also another light rate, lighter than the present, for domestic service.

Q. In your preliminary letter, you seem to propose a general rate in addition to the present system, because you calculate the income to be derived from that rate in addition to the present income?—A. Yes. I there take the law as it stands.

Q. Supposing it were determined to increase the water supply of Bombay, what system would you propose to establish for maintaining the present works and constructing the new ones?—A. A proposal has appeared in one of the public papers, I believe the *Times*. I think that proposal was originated by Mr. Andrew Grant, who unfortunately left Bombay just when he was about to lay down a substantive proposal. The proposal is this: The whole of Bombay benefits from the water supply, and the plan proposed is that all the properties in Bombay should pay a water rate, and that if any one chooses to have water into his house he should further pay an additional rate for that domestic service.

Q. Have you made any calculation of what those rates would be—first of all, the general rate; and secondly, for domestic service?—A. My letter is based on the existing system.

Q. By Colonel TREVOR—Do you consider the present rate high or low?—A. The present water rate for water through meter is high. It presses very heavily on the lower classes. The rate for private service is low.

Q. Do the lower classes have water into their houses?—A. Yes; at Nowrojee Hill I will show you hundreds.

Q. But there are 15,000 houses which have not water laid on, and these, I suppose, are the poorest?—A. No, I could show you several large chawls belonging to wealthy men who won't lay on Vehar water.

Q. Is it not the poorest houses, as a rule, which have not water laid on?—A. No, not as a rule. There are some districts supplied only from public sources—in the suburbs for instance.

Q. And do you think any house owner would lay on water in his house if he thought he could get it cheaper from the public taps?—A. That is a question of convenience.

Q. They get it more conveniently and cheaply than if they employed bheesties for the purpose?—A. I don't quite understand the drift of your question.

By COLONEL TREVOR—Does not everybody have it laid on because it is cheaper and more convenient to have water so than to have it brought in by bheesties?—A. Yes.

Q. And I suppose it is those who are richest who can afford to lay on private service taps?—A. I don't at all agree with you that the connections which are now in existence are laid on to the houses of those who are richest—far from it.

Q. It would cost some money to put in connections?—A. It depends upon the distance from the main; but it only requires a very small sum.

Q. But quite beyond the reach of the poorerst classes?—A. It quite depends upon the distance from the main; generally speaking, the poor class of houses are supplied as often as the richer class.

Q. What would be the effect of your proposed measure by which you would levy a rate upon all houses for the purpose of reaching those occupiers who have not laid on a private service?—A. Simply to equalise the pressure of the rate and increase the revenue. I think 7,000 properties paying for the whole water of Bombay is unfair.

Q. Don't they pay for their own conveniences?—A. Yes.

Q. And is it a tax then ?—A. Of course it is a tax.

Q. Do you call payment for service rendered a tax—when they can either leave it alone or take it, as they please ?—A. I don't think it is a question of having it or leaving it alone; some people attach more importance to having good water in their houses than others.

Q. Yes, some people have horses and like to ride, but do you call that a tax ?—A. Yes, like the wheel tax. There is no analogy in your argument. I say that experience has shown that there is not enough water, and that at present 7,000 properties are paying for the entire water supply of Bombay, which is consequently unfair.

Q. But they only pay for their own convenience?—A. It is unfair notwithstanding.

The CHAIRMAN—You see other people have the advantage of their payment for nothing. They not only pay for their own convenience, but for other people besides, inasmuch as other people get the benefit of the water supply.

Colonel TREVOR—But all have a right to draw gratis from the pipes.

The CHAIRMAN—But if everybody drew from the dipping wells gratis, there would be nobody to pay for the water.

Colonel TREVOR—You raise that taxation by putting such a price on the delivery of water in the houses that the person only pays for a special service rendered.

The CHAIRMAN—But he pays for more, for he pays for the water; which other people get gratis.

Mr. CRAWFORD—Supposing that everybody went to the dipping wells and got water for nothing, and assuming that nobody had domestic service, who would pay for the cost of the works ?

Colonel TREVOR—It should then be paid for by a general rate.

Mr. CRAWFORD—There you are fairly caught, for that is what I wish to arrive at. Waterworks must be paid for, you grant that. You want to make 7,000 properties out of 23,000 pay for it. I say—" Here is a great boon to the whole town. Let us levy a general water rate to pay for it, and let us make those who demand the further convenience of domestic service pay for that further convenience." This is the system followed in Glasgow and every town of note in England. It is intelligible and fair. The present system is unintelligible and unfair, to my mind; but as you (Colonel Trevor) are to a great extent responsible for it, it is hopeless that we can agree on such a point.

Colonel TREVOR—I don't see why the payment should be called a tax when a person pays for his personal convenience and for the sake of reducing his general expenditure.

Mr. CRAWFORD—I base my system upon that universally in force in England, and one obviously equitable and fair.

The CHAIRMAN—There is one other point upon which you can probably give us some information, and that is as to the cost which Mr. Aitken has put down for land in the different schemes.

Mr. CRAWFORD—For the area of the works ?

The CHAIRMAN—For compensation for land taken, and so forth ?

Mr. CRAWFORD—I think it is a very fair estimate.

The CHAIRMAN—Do you think these estimates will be likely to be exceeded ?

Mr. CRAWFORD—No; I don't think so. From the sales by the civil courts, we see that ordinary land runs from Rs. 125 to Rs. 150 an acre, and of course this includes a very large area of uncultivatable ground and waste land. I should say it was a very liberal estimate for a strip of land. The rate is taken at Rs. 100 per acre, except in Poway, which is a very valuable property. I bought land at Panwell at an average of Rs. 300 per acre for brick work, but the price was known to be a fancy one, and properly it should have been only Rs. 175 or Rs. 200, and that would have been all that would have been asked if the owners had not known it was for bricks.

This concluded Mr. Crawford's examination.

MR. CURSETJEE FRAMJEE, G.G.M.C.

By the CHAIRMAN—You are a graduate of the Grant Medical College, and a medical practitioner in Bombay ?—A. Yes.

Q. Will you give us your opinion as to the necessity for a further water supply ?—A. I have prepared a few notes, which, with the permission of the Commission, I will read. Witness then read as follows :—

"The natives prefer Vehar water to well water, but they are always in dread of water famine: two or three times in a year there is a complete stoppage of water for two or three days continuously,

and that always keeps them on the alert. Every native house has its well in its compound, and they draw from it to prevent the water going bad. They dislike the policy of Government closing up public wells, and on no account would close up their private ones. It is, as they say, their sheet anchor in times of failure of Vehar water supply. Again the supply of water is scanty and not continuous; the water does not rise up to more than thirty feet during the busy hours. Persons living on the second floor of a house can seldom get water for use unless they fill up large quantities at unusual hours, and as all cannot afford to collect that quantity at one time for use, they have recourse to their wells, although they do not like the well water so much as Vehar water. There is considerable leakage from the main pipes, and every householder dreads its effect in undermining the foundation of their houses. I have known two instances where house owners declined taking Vehar water in their dwellings; they were afraid the passage of water through the pipes might sap their walls and make them weak. The natives look to the great wastage of Vehar water in watering our streets: as only royal streets are watered, the poor envy the least drop of water wasted for the convenience of the rich. They would wish rather that water found its way into their mouths. A Parsee family of seven persons use 20 handas, or 100 gallons, of water for housewashing, bathing, and drinking purposes in a day. It comes to about 14 gallons per head per day, and they cannot manage with less. In February of last year, I wrote an article in a Guzeratee periodical styled 'Journal of Health' about the supply of Vehar water in Bombay. I expressed my opinion about the quantity supplied then per head as follows:—

"'The height of the water in the lake varies according to seasons. It is highest, that is 58 feet, in August, and lowest, that is 47 feet, in June. The water expended from the lake during the nine months when the lake does not receive any supply from the rains, amounts therefore to 11 feet height of water in the lake, which is equivalent to 2,134 millions of gallons, which amount to a supply of 8 millions of gallons in a day; and comparing that quantity with the population of Bombay it comes to 10 gallons per head per day. But as there is considerable evaporation from the surface of the lake, which amounts to nearly 5 feet in a year, the water actually passing out of the lake must be considerably less; and taking into account also the wastage and leakage, the actual amount cannot go above 6 gallons per head per day. When big drains will come in operation the quantity required for all purposes should amount to twenty gallons per head per day. If this quantity were allowed to pass, the water in the lake would scarcely last for six months more, even if the lake were allowed to flow empty. The lake is capable of holding nearly 10,000 million gallons of water if filled completely to its height, that is eighty feet; but the water collected from the surrounding grounds is not sufficient to fill it up. It is necessary therefore to make other arrangements to increase the supply by building another lake like Vehar, or make arrangements to allow the whole of the water falling on the surrounding desert to pour into the lake.'

"At present there are only 7,419 connections with houses out of nearly 25,000 buildings in Bombay. If we were to take on the average thirty persons to a house, we find that 222,570 persons receive the full benefit of the Vehar water; taking 14 gallons per head for their supply we find them using a little above 3 million of gallons per day. There are several dipping wells, drinking fountains, and stand-pipes, out of which the rest of the population receive 612,000 gallons per day; that is, the rest of the population receives only one gallon of water per day. Taking into consideration the quantity used for watering the streets, which amount to 200 thousand gallons per day, and that used for cattle and for the supply of ships, &c., the whole quantity spent does not seem to amount to more than 4 million of gallons of water per day. Mr. R. Aitken reports from actual observation that 8 million of gallons of water flow daily from the lake; it is not however corroborated by the calculation above given. It is either that householders actually use and waste large quantities, or that a large quantity is allowed to waste by leakage, or more water is used for other than drinking purposes; but the bare fact remains that the poor people do not spend more than one gallon of water per head per day. The dipping wells now constructed are worse than useless. The water carriers are filthy in their habits, and do not care dipping soiled vessels into the well water. Besides, there is so much water wasted that a dipping well is made out from a distance by the water-pool running into the street. The stand pipes are very few in number. Large crowds gather at one pipe, and I have often observed males and females mingled together and have all sorts of quarrels for obtaining water. These both require attention from the authorities. There is one cause why water does not flow higher than 30 feet. The connection between the main-pipe and the house-pipe scarcely exceeds three-quarter inch in diameter, and this is insufficient to allow a large quantity of water running high up. If the poor obtain water supply gratis as they do now, why not extend charity by allowing a certain quantity of water into their own houses, and charging them moderately whenever the quantity exceeds the usual supply allowed to them? As the poor have few wants, 5 gallons of water per day may be allowed per head gratis. As long as there are risks of Vehar water famine, the public wells must not be filled up, but preserved with care for future want. The tanks must also be cleansed and filled with Vehar water; no street water or sweeping should be allowed to pass in, and that water may then be useful at any moment."

By the CHAIRMAN—What scheme would you recommend for bringing the water home to the poor?—A. I think the poor people might have water given gratis to them at their own places.

Q. By connections with their own houses?—A. Yes, the connection should be made by the landlords, but the water should be supplied gratis to them at the rate of 5 gallons per head per diem, the quantity to be ascertained by meter.

Q. Don't you think it would be dangerous to give them water in that way when there are 700 living together?—A. No.

Q. Don't you think it would be injurious?—A. No.

By Colonel KENDALL—If a large number of persons were drawing out of the same tap, would it not soon get out of order; and never could be kept in order, in fact?—A. The public taps are injured by people crowding there, so it is probable that they would be injured in the houses too.

Q. But it would be worse in a house?—A. Perhaps so, but the damage could be recovered if pipes were injured or taps disordered.

By Colonel TREVOR—But it would be rather a serious work to undertake the inspection of houses? —A. If water is supplied to the poor it must be done.

Q. In the houses of the poor, are there, as a general rule, bathing rooms?—A. I don't think there are.

By the CHAIRMAN—Where are the people to bathe, in doors or out of doors?—A.—In the house.

Q. Don't you think it would be better in the compound than in the house?—A. The water might be kept in the compound.

Q. Would it not be still better to have it in a public street, where the authorities and inspectors could see if the cocks were in good order, and the water properly carried off instead of soaking into the soil?—A. They are always idle in their habits, and will not do anything if it involves much labour.

By Colonel TREVOR—They will use more water if they get it to their hand, and are not obliged to carry it?—A. Yes.

By the CHAIRMAN—Don't you think the object would be attained by having a larger number of supply fountains or stand pipes? Would not that be better than bringing the water into their houses? A. They must be numerous, or they would defeat their own object; each street or every 100 yards should have three or four stand-pipes.

Q. You say that in every 100 yards you should have three or four pipes?—A. I think so—at least in crowded streets.

Q. More water pipes than gas lamps?—A. They care less for light than for water.

By the CHAIRMAN—But would it not be better for them to draw water from the public supplies than from places in their own houses?—A. They would be too idle to fetch more water than they wanted.

Q. You mean they will fetch as little water as they can, and do without water for bathing even, rather than fetch it from a distance.—A. Yes.

By Colonel TREVOR—How do you think that 15 gallons would be consumed per head, and why that quantity is necessary for them?—A. That is, from the Vehar water in their own houses; without a meter they would squander and waste it.

Q. Is that an estimate?—A. Among the Parsees I estimate that 15 gallons per head is necessary; that is when the water is laid on in the house.

By the CHAIRMAN—Don't you think these private wells in houses, especially in the Fort, are very injurious to health?—A. I believe, as they have not been used for a long time, the water has got bad; but formerly when the water was used it was much better. The well water is not preferable to Vehar water, of course.

Q. Don't you think it would be a great advantage if many of these private wells were closed?—A. Not at present.

Q. You regard them as a safeguard against any failure of the Vehar water supply —A. Yes the natives keep them particularly for that purpose.

By Dr. HUNTER—It came out in evidence that in many places in the Fort the privies and drains were in close proximity to the well?—A. Yes.

Q. Would that not foul the water if there were cracks in the chunam?—A. Yes.

Q. In advocating that there should be stand pipes in the rooms of every house for the use of the residents, did it strike you that it would be neceesary for the inspector to visit the houses from time to time to examine the state of the cocks; do you think the inhabitants would object to this; and do you think they would waste the water if they got it in their rooms?—A. I believe if they got a certain quantity of water gratis they would never object to an inspector of the taps.

Q. Have you made any calculation as to the number of stand-pipes?—A. There are only a few stand-pipes.

Q. How many are sufficient for each hundred people?—A. I think one stand-pipe would be sufficient for one hundred, or more perhaps.

By the CHAIRMAN—You have just said that a good deal of the water in these private wells is very impure from circumstances of one sort and another—from drainage percolating into the wells, and

from the water not being disturbed; does not that render them a very unsafe supply to reckon upon in the event of a failure from Vehar?—A. The people always draw from the wells and prevent its getting foul.

Q. You said some of them caused disease?—A. The water is not as good as it was before when they were used largely.

Q. Don't you think using water from these wells would probably produce an epidemic?—A. Very likely; but it would do less harm than a water famine.

Q. Do you know if these water wells are ever cleaned by the owners—A. Before we got the Vehar water every private well was cleaned once a year before the rains set in; but now they don't pay any attention to them.

Q. I see you mention about 15 gallons per head per day as a necessary supply for a Parsee individual; do you consider Hindoos or Mussulmans would require more or less per head?—A. I think they would require less.

Q. How much less; in fact, how much should you think a Hindoo of the poorer class would require for personal use?—A. About five gallons.

Q. And a Mussulman more or less than a Hindoo?—A. About the same.

By Dr. HUNTER—Do you think a Parsee requires fifteen gallons, and a Hindoo from five to ten gallons per diem?—A. You will see the poorer Parsees using water for washing every morning, and they bathe every morning.

Q. You say that the wells were closed from time to time. Where was the water taken from while the well was being cleaned?—A. They sent in divers to get the mud out of the bottom; that was the way they cleaned the wells.

Q. They just took off the thick I suppose?—A. Yes.

By the CHAIRMAN—Do you think that the Parsees, from your knowledge of them, would be willing to pay extra rates for an additional water supply?—A. I believe they have always an objection to rates, but that they would pay willingly, for it would be the same as paying in another way. They would otherwise have to pay for fetching water, which would be more heavy.

The Commission then adjourned till Wednesday, April 7.

SIXTH DAY, WEDNESDAY, APRIL 7.

The following Commissioners were present :—

ANDREW R. SCOBLE, Esquire, *Chairman.*
Colonel KENDALL, R.E. | Lieut.-Col. TREVOR, R.E. | Dr. HUNTER.
Dr. LYON, *Secretary.*

The Commission resumed at 2 o'clock on Wednesday, in the Durbar Room, Town Hall.

MR. VENAYEKRAO JUGGONATHJEE SUNKERSETT.

By the CHAIRMAN—Would you be good enough to give us your opinion as to the necessity for increasing the water supply of Bombay ?—A. I think it very necessary that the water supply should be increased. At present there is great complaint that the Vehar water is not supplied to many of the streets and gullies. There is also less prejudice now against Vehar water than there was.

Q. Do you think there is any prejudice at all among any class of the native population of the town as to pipe water ?—A. Yes, there is ; but not so much as there was some years ago : the people have got accustomed to Vehar water and say there is nothing wrong in using it. It is my opinion also that more dipping wells should be erected in the native town.

Q. Do you consider dipping wells a more satisfactory manner of distributing the water to the poor than stand-pipes and fountains ?—A. I have seen no objection to dipping wells, but I think the others are apt to break. Dipping wells could be used by more persons at a time than stand-pipes could.

Q. If an additional water supply were obtained, do you think that there would be any objection to the imposition of a general water rate to pay for it ?—A. Yes ; I think there would be a very great objection, because the community are already very well taxed, and water should be made as cheap as possible.

Q. Then how would you propose to pay for the additional water supply that you consider necessary ?—A. I think that would pay for itself by giving it for irrigation purposes. There should be a committee appointed which should decide how much should be charged for 1,000 yards of gardens, and the supply should be charged for according to the pipes and not by meter, which is very objectionable and expensive.

Q. And what quantity of water do you think would be consumed for irrigational purposes within the island of Bombay ? What revenue would be derived from the sale of water for that purpose ?—A. In Bombay and neighbourhood I should expect from four to five lakhs.

Q. What do you mean by the neighbourhood of Bombay ?—A. I mean if the supply were extended out as far as Coorla and Sion.

Q. At what rate do you think the people would be willing to pay for the water for irrigation purposes so as to yield such a revenue ?—A. I would put it in this way : At present the charge for a *mote*—one of those wells from which water is drawn by leather buckets—is from Rs. 300 to Rs. 500 per month, and if you were to give the water at Rs. 100 less than what these cost, many would use the Vehar water.

Q. Have you any idea how many of these *motes* there are in Bombay ?—A. I have not, but I know many would be dispensed with if the Vehar water was got.

By Colonel TREVOR—How many gardens can you keep up from one *mote*?—A. One pair of bullocks will keep one garden at all events.

Q. What size of garden?—A. From two to three acres.

Q. More than that I think; about five acres?—A. Yes.

The CHAIRMAN—But that revenue, Mr. Venayekrao, could be derived only after the waterworks were in operation. How would you get the funds to pay for the construction of the works?

Mr. SUNKERSETT—They should be taken up by the State; there is no other help for it. The Municipality is sadly in want of funds and cannot afford it.

By Colonel TREVOR—Do you think Bombay has any particular claims on the State beyond any other town?—A. No; but in other towns the water was taken up by the State, and we have already the Vehar works to pay for, and the community is not prepared to pay for an addition.

Q. Then you do not advocate an increased water supply at the cost of the Municipality?—A. No; I don't think we ought to throw the burden on our successors.

Q. Not even if you give them an increased water supply?—A. I don't think so.

By the CHAIRMAN—Supposing such an event as the bursting of the dam at Vehar and the stoppage of the supply from that source, what do you think would be the consequences to Bombay?—A. The consequences to Bombay would be very grave. There would be a water famine, but I am not an advocate for shutting up all the wells and tanks.

Q. Do you think the wells and tanks, which at present exist, would form any adequate source of supply in case of the failure of Vehar?—A. I think they would not; but at the same time they would to some extent alleviate the famine.

Q. To any considerable extent?—A. No; only to a small extent.

Q. I suppose you know the condition of the most of the large tanks in Bombay, do you not?—A. Yes.

Q. Are you a trustee for any of the large ones?—A. No.

Q. Are you aware that the tanks at Bholeshwur, Mombadavee, and Walkeshwur are used very largely by the people as bathing-places and places for washing clothes?—A. Some of them are, but where there is a prohibition they are not used. At Mahaluxmee and Bholeshwur they are used for bathing, and at Walkeshwur they draw out the water.

Q. May we not safely say that none of the tanks that have religious associations connected with them would be available for the water supply?—A. At present the water at Walkeshwur is used for drinking purposes, as that is the only place in the village. There is a well in the neighbourhood of Government House, and the people largely use the water there.

Q. I believe the water in these large tanks is very foul, is it not?—A. In some instances it is foul because it is not drawn off. In some places, wherever there is Vehar water, the water of the well is allowed to remain in it and consequently gets stagnant, whereas were it used for washing purposes it would not get so.

Q. Then there is, as to many of these tanks, no provision whatever for changing the water?—A. In some cases the tanks are cleared out every fourth or fifth year, but in others the water is left unchanged.

Q. Some of these tanks are largely frequented, are they not, by certain classes of religious persons who actually live on the margin of them?—A. Not quite on the margin, but in the immediate neighbourhood.

Q. And they have no other accommodation at all, but live in the open air on the borders of these tanks?—A. Not during the monsoons; they erect temporary sheds.

Q. But during the dry season?—A. Yes; they then live in the open air. At Walkeshwur they have privies by the seaside. I don't know about Bholeshwur and Mombadavie, but I believe they have them there.

By Dr. HUNTER—On the banks of the tanks?—A. No; for instance near the temple at Bholeshwur there is a large range of buildings.

By the CHAIRMAN—In regard to the wells in private houses, many of these are open to the same objection that you have stated as to the tanks, are they not? People bathe and wash their clothes around them?—A. Yes; but in some cases the wells are so constructed that none of that refuse water gets into the wells.

Q. Is it not very rarely that the basement round the wells is built so pucka that the refuse water cannot come in?—A. That is very rarely the case.

Q. There is some difficulty in getting means of changing the water, is there not?—A. Before the introduction of the Vehar water they used to have the wells regularly cleaned out every third or fourth year, but I believe they do not do anything of the kind now.

Q. Some of them are very foul?—A. Yes.

Q. Have you ever heard of anybody having been suffocated by going down these wells?—A. I have not heard of any late instances.

Q. Are not these private wells frequently in the immediate neighbourhood of cesspools?—A. Some are, and some are at a convenient distance.

Q. Do you think, that in the event of the failure of the supply from Vehar, the water from these private wells and large tanks could be relied upon as safe for drinking and culinary purposes?—A. I think that it might be used for culinary purposes, but in many cases not for drinking. In some cases the water in the wells is exceedingly good, as good as the Vehar water itself. At Breach Candy there is very good water.

Q. In the event of an increased water supply being obtained, do you think it would be advisable to carry the water into the houses occupied by the poorer classes?—A. I would have dipping wells near; the houses of the poor are so ill-constructed that I don't think it would be well to carry the water into the houses.

Q. How about bathing; do you think it is necessary to increase the facilities for bathing?—A. Yes.

Q. If public bathing places were set up in various parts of the town, do you think the poorer classes would resort to them?—A. Yes; if it were publicly known to them that such places did exist. They resort to all these tanks for bathing purposes; the great mass of the Banians go to the Mombadevie tank.

Q. In the same manner, do you think that facilities should be given for washing clothes?—A. Yes, I think so; since the introduction of the Vehar system, the people generally use the well water for bathing purposes.

Q. From your experience of the Hindoo population, about what quantity per day do you think is required; I don't say by the better class of Hindoos, but the poorer classes—the most numerous class—how many gallons a day do they require?—A. The poorer classes generally divide their consumption into two parts; first they store up the water they use for bathing and other purposes, and for drinking purposes keep a chattie full or *handee*.

Q. What is the ordinary number of a Hindoo family?—A. Sometimes fifteen or twenty.

Q. Taking a family of fifteen or twenty, how many handees would they get in in the course of a day for their domestic use?—A. From three to four.

Q. For washing?—A. No, for drinking purposes.

Q. I mean for all domestic purposes?—A. About ten or twelve.

Q. A handee holds from three to four gallons generally, does it not?—A. Yes.

Q. Would that supply include what they would require for their animals?—A. No; that would not include their animals. They do not generally use the Vehar water for animals.

Q. Have you any idea of the number of cows and buffaloes that are kept in Bombay besides the animals that are used for draught purposes—those that are registered for wheel tax? Can you form any idea of the number?—A. It is impossible to tell the exact number; but each family generally keep either a cow or a number of she goats.

Q. Have you any notion at all of the number of cows that are probably kept by Hindoos, I mean privately, not by cow-keepers?—A. They would amount to more than 2,500; that is only a guess; I cannot tell you the correct number.

Q. Then do I understand you to say that notwithstanding the danger to life that would result from the failure of the Vehar water supply, and the impossibility of trusting to the supply from tanks and wells, you nevertheless think that the native population generally would object to the levy of a general rate for the extension of the water supply of Bombay?—A. They would prefer that Government should take the matter up.

Q. Yes; naturally they would prefer that; but do you think they would object to pay a general water rate in order to prevent the possible occurrence of the evils you have spoken of?—A. Well, if it comes to that ultimatum, the community must pay, but they are very heavily taxed, and they look to Government to provide them with the means of having water; but if they are driven to that necessity, a light water rate might be imposed.

Q. What do you understand by a light water rate; two or three per cent. upon the house assessment?—A. The house assessment is already very heavy.

Q. Is there any other point upon which you wish to give your opinion?—A. No.

The CHAIRMAN—Then we will not detain you any longer.

The witness then withdrew.

MR. RUSSEL AITKEN, *Examination continued :—*

The CHAIRMAN—In what state do you think your steel main three-eighths of an inch thick would be at the end of 30 years?

Mr. AITKEN—Well, as I think I have stated in my report, I believe steel is much more durable than wrought iron. Steel lasts in boiler tubes, where it is exposed to great variation of temperature, very much longer than wrought iron. Wrought iron plates one quarter inch thick, in barges, have lasted for forty or fifty years. The first iron boat that was constructed for the Forth and Clyde Channel is now working.

Colonel TREVOR—That would hardly be any criterion for the main. What would stand for a boat would not stand for a pipe.

Mr. AITKEN—That is a matter of opinion however. As I say in my report, when the main is worn out Bombay will be doubled and able and willing to pay for a new pipe.

The CHAIRMAN—Do you think it not improbable that a new main would have to be substituted at the end of thirty years?

Mr. AITKEN—I think it is not improbable that will be the case in 40 or 50 years; but I beg to observe, as I have stated in my report, cast iron pipes are not imperishable in Bombay. Many of the pipes of the Vehar works are completely eaten away from the outside.

Colonel TREVOR—You see it makes a considerable addition to the cost of the work if it has to be renewed at the end of 30 years.

Mr. AITKEN—In the other scheme, you would have to renew your engines, also the iron work of the aqueduct and many of the works.

Colonel TREVOR—You would have to renew your engines, but not the aqueduct.

Mr. AITKEN—I should like to call attention to the Glasgow water works. When the Loch Katrine works were proposed, the Admiralty made great objection to taking water from Loch Katrine and leading it into the Clyde. The whole weight of the Admiralty was against taking water from Loch Katrine and in favour of pumping it from Loch Lomond, which is about half the distance from Glasgow that Loch Katrine is. I find it stated that if, as had been proposed, water was taken from Loch Lomond, for the supply of Glasgow, the cost of pumping water, if capitalised, would have amounted to 40 or 50 lacs of rupees. Coal in Glasgow varies from Rs. 5 to Rs. 6 per ton. In Bombay the cost is Rs. 33. That is the average that the mills pay all the year round. Of course the engines which were formerly used for pumping water from the Clyde for the supply of Glasgow, were abandoned for the high level system. But calculating that the engines in Bombay would work with the same expenditure of coal that the Glasgow engines wrought with, then to raise 25 million gallons every day the height of a hundred feet—which would be required for the low level system—we would require an expenditure of 60 tons of coal per day. In my former calculation I have only given 30 tons, so that I have been very moderate. The whole of the details of the actual cost of pumping at Glasgow are given in Mr. Gale's Report, and are the result of the working of a number of years. Taking an average for a length of time, the figures show 186,000 foot pounds per lb. of coal. Taking that calculation, it would be 60 tons every day for pumping up water for Bombay. Of course if you only pump up as much as the Canery supply the cost would be only 30 tons per day.

Colonel TREVOR—There is a correction Captain Tulloch wishes made. He thinks that the water should be raised only fifty feet instead of a hundred.

Mr. AITKEN—It is very well to wish to do that, but if that were so, the discharge would not be sufficient, as many of the houses in Bombay are very high, and I don't think you could supply Bombay with that low pressure.

Mr. CRAWFORD—I think you rather over-estimate the cost of coal at Rs. 33.

MR. AITKEN—I have taken the price on enquiry from the contractors who supply the spinning mills in Bombay.

Mr. CRAWFORD—My argument is that a much fairer way would be to take the price from the P. and O. Company, who are the largest consumers, and that would be Rs. 25 per ton.

Colonel TREVOR—The estimate is rather higher than the railway price. I can state that for the last two years their price has been Rs. 30, but sometimes it has been down to Rs. 15. The price is very irregular.

Mr. AITKEN—But the cost of cartage would be Rs. 3 to Coorla, and I don't think you can take the estimate at much less than Rs. 33. With regard to the engine power required, it is very seldom that an engine works up to the nominal horse power, because the speed of the piston is in pumping engines so very low. I find that Mr. Gale's paper—which is really most reliable, because he had charge of these works not only in an experiment but in actual working for a number of years—states that to pump 25 million gallons to a height of a hundred feet, would require 900-horse power. Constantly working formerly gave 550-horse power as the power which would be required for the engines; but more would be required, as they do not generally work up to their nominal horse power. Spare engines would also be required.

A long list of questions which had been handed in by Captain Tulloch with a view to further examination of Mr. Aitken were then discussed. In considering whether these should be asked, some of the Commissioners expressed their opinion against going into further evidence, but on Colonel Kendall's suggestion, it was agreed that he should put some of Captain Tulloch's questions to Mr. Aitken.

Mr. AITKEN, in the course of further examination, said he had estimated the cost of the Shewla scheme at Rs. 1,40,00,000, whilst Mr. Ormiston, however, had estimated it at Rs. 2,00,00,000, Mr. Ormiston, however, had over-estimated the price of steel—Captain Tulloch had admitted that. The greatest pressure on the steel mains would be 135 lbs. Mr. Blaney had made somewhat of a mistake when he stated that as the water would be delivered in Bombay at a pressure of 80 feet, that they might make the pipes much thinner, but he had forgotten that it might be necessary to shut a sluice at Coorla and so give the maximum pressure all the way back. As to pressure in the main, it would not be necessary to stay or stiffen a steel main as was always done in making steel boilers. Mr. Blaney had also made a rather curious remark to the effect that a cast iron pipe would stand blows from a 40 lbs. sledge hammer. But cast iron pipes were brought out in masses of four tons, and it was not a blow from a sledge hammer, but weights of four tons coming against each other that broke the pipes. As to the pressure on the main, he had had data on which to make his calculations,—that of the Manchester Boiler Association. In that case boilers were exposed to great heat and were cooled down at night, and the steel so used had always given great satisfaction. He did not think there was much fear of the main bursting. Of course they would have Armstrong's patent valves, which would shut at once whenever a breakage took place in the pipes. He did not think there was any danger to be apprehended from that source. They had an Armstrong valve at Coorla, it had been used several times, and it had always acted efficiently. He might say that there was an objection to everything new. For instance, he remembered when he was a pupil of Mr. Walker, he was ordered to look up the subject of revolving floating lights, and he found in the old system they were subject to sticking. He devised a new system of machinery which was adopted by Mr. Walker, although at first Mr. Walker had some doubts about adopting it. But now it was in use on board the outer light ship in Bombay Harbour, and was very generally used. He proposed to get out the main from England in curved plates partly rivetted together, and he would complete the riveting on the spot. He did not anticipate any difficulty in getting rivetters, for there were a great number of smith's hammermen to be had, and they were sufficient. As to the durability of a steel main, he thought it would last for 40 or 60 years. For instance, he might mention that it was always prophesied when iron ships were first made, that they would never last. But it was a most astonishing circumstance, that after an iron ship had been painted half a dozen times and been in use for 30 years, a hole had been drilled in her, yet no one could detect any diminution in the thickness of the plates. He proposed to carry this main above ground, and he did not think that by so doing the temperature of the water would be increased, inasmuch as the pipes, before they came into Bombay, would be underground, and after the water arrived in Bombay, it would pass underground, through the ramifications of the pipes. Therefore the water would be of the same temperature as the ground. He did not think there was anything in what Mr. Blaney had said about the water arriving in Bombay in a state fit to boil eggs in.

By Dr. HUNTER—He had estimated the variations of the temperature at 70°. If the water was brought down in an open duct, it would be quite as hot, if not hotter, than if brought down in a

main. True enough, a steel main would be exposed to the sun's rays at a temperature of 125°, but they must remember that there would be a great quantity of water in it, and that the heat of the sun would only go on for two or three hours in the day, and that would not be enough to heat such a mass of water. Although the temperature of the sun was 125° in the heat of the day, it was only 72° at night.

Dr. HUNTER asked if it was not more than that in the Konkan in the hot weather? It was very rarely less than 80° in Bombay at night in the hot season. The water in the Vehar pipes was very warm by the evening, was it not?

Mr. AITKEN replied that it was, but that by the time it went through all the distributing pipes in Bombay, he thought it would have acquired the same heat as the ground. He thought there was nothing in the suggestion as to the heating of the water. In further examination by Colonel Kendall, Mr. Aitken explained some of the operations in connection with the laying of the mains, and promised to send in copies of diagrams, &c., relating to the steel main. When a burst took place, there were, he said, two difficulties with regard to cast iron pipes: one was getting a heavy pipe of four or five tons weight to its place, and another, the difficulty of getting rid of the water left in the pipe. The steel main, however, would be above ground, and the water could easily be let out of the pipe; whilst again, there would be no difficulty in bringing a single plate of steel of 3 cwt. or 4 cwt. to carry out any repairs that were necessary. A steel main could easily be tested much above its working pressure before it was brought into use, and he did not think there would be much fear of its bursting. They seldom heard of locomotive boilers bursting, and yet there were miles of such tubes exposed to an enormous pressure and to a great deal of jolting from the moving of the engine. In America locomotive boilers were only quarter inch thick and worked up to 150 lbs. pressure of steam. These were wrought iron boilers, whereas this main was proposed to be steel, subject to hydraulic pressure, which was less destructive than steam pressure. Mr. Aitken then referred to the suitability of the country for bringing in a water supply from Bhewndy, and said he would send in a detailed report. He had surveyed this district, and did not think it was favourable for an aqueduct. He thought that if Captain Tulloch would take a look at the country, he would have a much better notion of the difficulties to be overcome than by remaining in Bombay.

Captain TULLOCH said he was satisfied at all events as to his own knowledge of the country for 18 miles round Bombay.

SEVENTH DAY, SATURDAY, APRIL 17.

The following Commissioners were present :—

ANDREW R. SCOBLE, Esquire, *Chairman.*
Colonel KENDALL, R.E. | Lieut.-Col. TREVOR, R.E. | Dr. HUNTER.
Dr. LYON, *Secretary.*

The Commission resumed at 2 o'clock on Saturday, in the Durbar Room, Town Hall.

Mr. CHRISTOPHER THWAITES, C.E., *Examined.*

By the Chairman—Are you the Engineer in charge of the Bombay Drainage Works?—A. I am the acting Executive Engineer to the Municipality.

Q. Are you in charge of the drainage works at present proceeding in Bombay?—A. I am.

Q. Will you be good enough to give us a description of the present arrangements for the drainage of Bombay?

Mr. Thwaites—With reference to the drainage, or the method of disposing of the sewage?

The Chairman—With reference to drainage itself.

Colonel Kendall—With reference to the whole system since you were in charge here, and any recent improvements from the time you have been connected with this drainage. We wish you to describe it, so that we may thoroughly understand the existing system of drainage, and that the matter may be made quite apparent to any one reading the report.

Mr. Thwaites—It would be difficult to explain the whole system of drainage verbally, but I have prepared a plan of the existing drains which will show you better than any description that I can give. This plan shows the existing drains in the native town, and I can best answer your question by explaining this plan (plan produced). This is a tracing of the native town. The town, for the purpose of drainage, is divided into three parts,—one which drains northwards into the main drain, a portion to the west which drains into the harbour; the remaining portion drains into Back Bay. The old main drain commences at the Esplanade, passes up Syud Abdool Rahimon street across the Parell road into Bappoo Kote street, passes the southern end of Duncan road and runs under the Falkland road to the B. B. and C. I. Railway station, where it reaches the flats, and changes from a covered sewer to an open cut drain. The Love Grove sluices and pumping station are placed at the end of the main drain where it discharges into the sea. The main drain disposes of the drainage of the districts right and left through which it passes.

Q. The summary of all this is, that the bulk of the sewage of the native town is carried off by the main drain to Love Grove sluices, where it is pumped into the sea at all states of the tide?—A. Yes.

By Colonel Kendall—What is the size of the drain?—A. It varies in size. I will state the different sizes. It commences with a drain of 2 feet by 2 feet.

Q. And what is the section?—A. A square bottom with segmental arch.

Q. What is it constructed of?—A. Rubble in chunam in the walls and invert with a roughly dressed stone arch; but in some places no masonry invert has been found.

Q. Could you describe the sections from street to street. We want a description of the drain on paper?—A. It varies considerably. I will give it you from the section.

Colonel Trevor—Perhaps you will say what are the sizes.

Mr. THWAITES—I can give it you from the sections. At its commencement in Syud Abdool Rahimon street, it is 2 feet wide by 2 feet high. The section of it is square. At 2,350 feet from the commencement of the sewer, its size is 10 feet 9 inches wide by 4 feet high. The inclination is 1 in 451. It then runs on to 3,800 feet, and becomes 12 feet wide by 5 feet 6 inches in height, with a slope of 1 in 270. Up to 4,900 feet, the size is 20 feet 3 inches wide by 9 feet in height, and the slope is 1 in 488. At 6,500 feet the size is 20 feet three inches by 9 feet, and the inclination 1 in 941. At 7,950 it is 20 feet 3 inches, but the height is 8 feet six inches, and the slope is 1 in 4,677—that is, almost level.

Dr. HUNTER—In the absence of any system of flushing and with so little slope, there is no wonder that the drain smells so much.

Mr. THWAITES—At 9,650 feet it is 20 feet wide by 9 feet 10 inches in height, and the slope is 1 in 1,141. The arching then ceases, and the main drain runs over the flats to the sluices as an open cut.

Colonel KENDALL—The construction, you say, is rubble?—A. Yes. The arching is of roughly-dressed stone.

Q. And the channel?—A. That is in rubble also; but a rubble bottom has not been found in all cases.

Q. The bottom is flat?—A. Very nearly flat.

Colonel KENDALL—Now perhaps you will describe the subsidiary drains in something the same way. That will give us some record of the matter?—A. I cannot give you the size or the slopes of all the subsidiary drains. That would involve opening up a number of streets in the town, as we have no records of the whole of them.

Q. Do you not send men in to clean the drains?—A. Yes, men are often sent in; but that comes under the Health Officer's duties.

Q. Cannot they give you that information?—A. They would not be able to give us information that we could rely upon.

Mr. AITKEN (to the Commissioners)—I can give you that information.

Mr. THWAITES—I am now alluding to the existing system of drains.

Colonel KENDALL—Perhaps you will describe where the drains run now.

Colonel TREVOR—Every street has its drain, has it not?—A. Every street has its drain, and all these drains slope towards their main outfall sewers. In the native town most of the drains slope towards the main drain.

By the CHAIRMAN—Is there no connection between the houses and these street drains?—A. The gullies between the houses all drain into the existing drains.

Q. Then what passes through it; what description of sewage passes from these street drains into the main drain?—A. A large portion of the solid night soil is removed by halalcores. A portion, however, of the night soil, with the urine, bath-room and cook-room water, and some of the rainfall, passes into these drains.

Colonel KENDALL—Have you any information as to the size of these subsidiary drains?—A. We have not the sections of all the subsidiary drains in the native town. I believe in many cases these drains were made without any regular plan.

Q. When was that the case?—A. I believe the drains were constructed in that way in olden times.

Q. What do you call olden times. How long have you been connected with the Municipality?—A. Over four years. I mean before my time. Whenever we have constructed a drain, there have been regular plans and sections made.

By the CHAIRMAN—Have any new drains been made in this part of the native town during your connection with the Municipality?—A. Yes; we have made drains at Camateepoora, and we are now completing that system of drainage. The Camateepoora district drains into the Oomercarree sewer, which falls into the main drain in the Falkland Road. We have three brick sewers running down the three main streets of Camateepoora, namely, Cursetjee Sooklajee street, Centre street, and Bazaar street. These take all the drainage of the side streets. The brick sewers are 3 feet 9 inches high by 2 feet 6 inches wide, and are oval or egg-shaped. They have cement inverts with arches in chunam. The slopes vary from 1 in 500 to 1 in 525, and twelve-inch earthenware pipes run under the centre of each cross street and drain into the brick sewers; the slopes of these 12 inch pipes vary according to the level of the street. These drains are in every case constructed with as good a fall

as can be obtained. They are all laid down in the plans and sections, and, if you desire it, I can give you the gradient in each case.

By Colonel KENDALL—Are not the drains connected now ?—A. Wherever we can do so, we invariably connect them with the houses by means of the gullies, which take everything into the drain except stable refuse and so forth, which is prevented from entering by gratings. We find that an immense quantity of liquid sewage does find its way into the sewers from that district. Since the Camateepoora district was connected with the main drain, we have found an immensely increased flow of sewage in our main drains, and our pumps have found it difficult to pump away the whole of the sewage.

By Colonel TREVOR—Is the system of sewers complete now ?—A. Not quite. Seventy or eighty feet of the sewer in Bazaar Street have yet to be constructed. The drains running from the Bellasis Road to the Oomercarree sewer road are complete.

Q. These drains tap the drainage on the northern side, do they not ?—A. Yes.

By Colonel KENDALL—How does the house sewage find its way into the drains ?—A. From the gullies, the drainage from which finds its way into the main drain. There is not a separate drain from each house. The houses there are very small, and the frontage of each house does not average more than 15 or 20 feet. They mostly drain into the gulley running between the houses. Between each two rows of houses there is a gulley, into which nearly all the waste water is discharged.

By Dr. HUNTER—Are the gullies open ?—A. Yes, nearly all of them are. They are generally paved, and have a slope from the two rows of houses. The gulley separates the two compounds, and the water finds its way along the junction of the stones forming the bed of the gulley. There is just room enough for a bunghy to pass along the gulley.

By Colonel KENDALL—Has any record been kept of the quantity of sewage passing through the main drain ?—A. Yes; some experiments have been made as to the quantity, but as yet no very exact results have been obtained.

Q. Can you give us an approximation of the quantity ?—A. I have not the figures with me, but I can get them for you.

Q. I should like to see them. Then have you any idea of what the velocity of the flow of the drainage would be through the main drain ?—A. I do not know the exact velocity; but it is very slow indeed.

Q. Do you find that in some places the drain gets blocked up and choked ?—A. Yes. It has to be opened frequently, and great inconvenience is caused by the roads being broken up.

Q. Perhaps you will say how you manage to clean the drains, and show us where the obstructions occur ?—A. The cleaning of the drains belongs to the department of the Executive Health Officer, and not to that of the Executive Engineer. The Executive Health Officer will be able to give you the information.

Colonel KENDALL—Is not the Executive Engineer consulted by the Health Officer, or his opinion called for by the Health Officer ?

Mr. THWAITES—As to what points ?

Colonel KENDALL—As to the general state of the main drain. I should have thought this was a professional question which ought to be dealt with by the Engineer, and not by the Health Officer.

Mr. THWAITES—If it were a question of a drain being put in a proper state of repair, or anything of that kind, it would come under the Engineer's Department; but if it were a question of scavenging, or removing the deposit of the sewage, it would come under the Health Department. In any case affecting the drain itself, reference is made to the Engineer's Department.

By Colonel KENDALL—Do you not constantly find, in places where the level is low, that the drain becomes blocked up and overflows from the water being collected there ?—A. The drain never overflows in the town during the dry season, but when the monsoon is on and there is a very high tide, it overflows, as happened last year during the extraordinary rainfall of the 9th August last. If it happens to be a high tide during a heavy rainfall and you cannot open the sluice gates, then the water accumulates on the flats and overflows the town.

Q. What causes any flow in the sewage at all in a portion of the drain where there is only a fall of 1 in 9,650 ? Are any artificial means employed to make the sewage flow through that part of the drain ?—A. An inclination in the surface of the water will cause the water to flow along a sewer or pipe although the channel may have no slope.

Q. Then you do find that the sewage flows along that length ?—A. Yes; it does flow, but with decreased velocity. There are many rivers with a far less slope than this drain.

Colonel TREVOR—I think all the Madras canals have a fall of three inches only.

Mr. THWAITES—The Mississippi and other large rivers have inclinations of only a few inches per mile.

The CHAIRMAN—Have any new drains been completed of late, besides the Camateepoora drains? —A. Yes, there is a large outfall drain at Sonapoor.

Q. That goes into Back Bay?—A. Yes; and drains the Dhobie Talao district.

By Colonel TREVOR—That is only a surface drain?—A. It takes the surface water and whatever else finds its way through the gullies. The drain is very offensive at times.

By the CHAIRMAN—Is it a covered drain?—A. Yes.

Q. Then on the harbour side, what drainage is there there? What is the drain for the Doongaree Cooley street district?—A. There is the drain which runs down the Esplanade Cross Road, past the Scotch Free Church, and then to the harbour. It was intercepted by the reclamation which the Government are carrying on, and they have continued the drain by a square box drain as a temporary measure. The sewage from that flows into Moody Bay. There are also two drains which formerly ran into the old Carnac basin, but which are now intercepted by the Elphinstone Company's drain which discharges at the end of the new Carnac Bunder.

Q. What district does that drain?—A. The district to the west of Doongaree Cooley street and the parallel streets up to the watershed line of the main valley which slopes to the north. It also takes the water from the Esplanade. In fact, it is our main outlet for the monsoon water from the markets and the Esplanade.

Q. To what point west does it go?—A. As far as this line (pointing to the plan).

Q. That is nearly as far as the Musjid Bunder?—A. A little further than Musjid Bunder.

Q. There is another drain at old Chinch Bunder?—A. Yes.

Q. Then these three drains you have described drain the native town?—A. Yes. Besides these, there are two drains in Churney road on the western side of the town which have been intercepted by the Back Bay Reclamation, and which are now being provided for by being carried through the Reclamation.

Q. Then the Fort drain flows into Moody Bay, and this one in Churney Road into Back Bay? —A. Yes; there is also another drain higher up, at Chowpatty.

Q. Does that drain Chowpatty?—A. Yes, a portion of Chowpatty. Both the drains in Churney Road are large open side gutters.

Q. All running into Back Bay?—A. Yes.

Q. How many drains are there altogether that run into Back Bay?—A. There are drains at Chowpatty, Churney Road, opposite the English burial ground, the Sonapoor main drain, 1st Marine Street, two in the Marine Lines, and two from the Esplanade near the Bandstand.

Q. How is Malabar Hill drained? Are there made drains, or is the drainage natural only?—A. There are drains along the sides of the roads, into which the water from the houses passes; the water then runs down the hill, and the greater part is either evaporated or absorbed by the ground.

By Dr. HUNTER—It is only surface drainage there?—A. Yes.

Q. There is no real system of drainage on Malabar Hill?—A. No.

The CHAIRMAN—That is merely a stone-faced gutter?—A. That is all it really is.

Q. Then the first made drain is at Chowpatty?—A. Yes.

Colonel TREVOR—That is the one made by the Back Bay Company, is it not?—A. Yes.

By the CHAIRMAN—Where is the next point at which there is a drain?—A. The one at Churney road.

Q. Then where is the third?—A. There is another opposite the English burial ground. All these drains were intercepted by the Back Bay Reclamation. They drain the upper portion of the Sonapoor district, part of Girgaum, and Khetwaddy.

Q. The next one is what you call the Sonapoor main drain?—A. Yes.

Q. Whereabouts does that run?—A. Into Back Bay, from the end of the road which passes Trinity Chapel.

Q. It drains Dhobie Talao, I suppose?—A. Yes.

Q. Then the next drain is the one in the Marine Lines?—A. There is one in 1st Marine Street, and there are two in the Marine Lines. They were made, I believe, by the trustees of the Esplanade Fee Fund.

Colonel TREVOR—No, by Government.

By the CHAIRMAN—I suppose these are all the drains which run into the sea, until you come to Colaba ?—A. There is one at the Commodore's bungalow.

The CHAIRMAN—Do all these drains run through the Reclamation Works ?

Colonel TREVOR—Yes.

The CHAIRMAN—Well, that seems to dispose of the means of drainage for the native town and the Esplanade.

Colonel TREVOR—The Esplanade is not drained at all.

Mr. THWAITES—There is partial drainage along the Esplanade Cross Road.

The CHAIRMAN—Then there is no made drain for the Esplanade, except these small ones in the Marine Lines ?—A. I believe there are one or two small drains across Rotten Row, to carry off the water from the centre.

Colonel KENDALL— You are only speaking of the storm water now, not about the sewage ?—A. Yes ; not sewage drains.

Colonel KENDALL—But you had better not mix up the two.

Mr. THWAITES—I merely mentioned in answer to the Chairman that there were one or two surface drains on the Esplanade for carrying off the monsoon waters.

The CHAIRMAN—Well, then as to the Fort, what is the system of drainage there ?

Mr. THWAITES—The Fort is drained in a similar way to the native town, but we have constructed a main sewer which commences on the Esplanade, runs down Church Gate Street, crosses the Elphinstone Circle, passes between the Town Hall and the Town Barracks, and between the Arsenal and the Mint, and discharges into the harbour. Brick sewers have also been constructed along Bazaar Gate Street, Hornby Row, and the Eastern Boulevard.

By Dr. HUNTER—Where does the sewage from the Fort drain go to ?—A. The whole of the drainage of the Fort is discharged between the Mint and the Arsenal, where there is an outfall into the harbour.

Q. What is the gradient in Church Gate Street ?—A. One in 500. It commences at 1 in 800. There is a short length of 1 in 100.

Q. Where is the gradient of 1 in 100—at the outfall ?—A. Yes ; for a few feet.

Q. And the average would be about 1 in 500 ?—A. Yes. The upper part of the drain has a much better slope, 1 in 200. In Elphinstone Circle it is still better, 1 in 100; and in one place, 1 in 65. I can give you the whole of the slopes if you wish for them.

The CHAIRMAN—How far out is the outfall carried into the harbonr ?—A. To the edge of the present reclamation.

Colonel KENDALL—But with reference to low water mark ?—A. The sewage is not carried out to low water mark ; it is discharged at about four feet below ordinary high water mark.

Colonel KENDALL—I thought you were carrying the outfall further out, by means of a large iron pipe.—A. No.

Colonel KENDALL—But I understand that was the intention ?

Mr. THWAITES— Perhaps you allude to the old Chinch Bunder outfall ?

Colonel KENDALL—No.

Mr. THWAITES—That was not the intention when it was sanctioned by Government.

By the CHAIRMAN—Are there small sewers in every street in the Fort ?—A. Yes ; there are the old drains ; I have sent for a plan which will show them all.

By Colonel KENDALL—Are they open or covered ?—A. They are nearly all covered ; the water finds its way into them through the five-holed stones and gullies ; in most cases the drains run down the centre of the street ; this used to be the case in Church Gate Street.

Q. What depth are they below the surface ?—A. They vary in every street ; they are very near the surface. I don't suppose the average would be more than between three and four feet for the small drains. They are mere cesspools; in fact, there only is a good flow in them during the monsoon ; they are then flushed, not otherwise.

The CHAIRMAN—Are there many houses in the Fort connected with these drains ?—A. The houses in Bazaar Gate Street, &c., are in every case connected with the new sewers, and all the small drains are connected with the same ; only a portion of the solid sewage finds its way into them, as there are no water closets to the houses.

The CHAIRMAN—In the Elphinstone Circle they have water-closets ?—A. Yes ; that is the only place in Bombay.

By Dr. HUNTER—I don't understand you. How about the opening of these drains with reference to the high and low water mark?—A. The invert of the outfall is situated at about four feet below ordinary high water mark. There are gates at the entrance to prevent the influx of the sea.

Q. You have no means of keeping out the wind; the gates are about four feet below high water mark, and the flow of the tide is fifteen in Bombay?—A. These gates prevent it; they are in a recess. They keep out the wind, and prevent the sea water rising in the sewers and the waves from dashing into the sewer during the monsoon and breaking up the work.

Q. Is the sewer ventilated?—A. Yes, by means of man-holes and shafts from the surface of the street into the sewer; there are catch-pits placed so as to prevent the road scrapings and rubbish finding their way into the sewer, and iron gratings to allow the gas to pass into the street. In some places we have charcoal screens; there are some in Bazaar Gate Street and the Elphinstone Circle.

Q. How are they arranged?—A. They are vertical screens made of wire-work in an iron framing filled with small pieces of charcoal, and placed so that the gas has to pass through the charcoal before it makes its escape.

Q.—What is the thickness?—A. Four inches between the two screens; it is a stratum of charcoal in wire-work.

Q. Is the charcoal powdered or whole?—A. It is in small pieces; but I think more harm than good is done by this, because it stops the ventilation, and the gas becomes very foul from being confined.

Q. At what intervals are these ventilators placed?—A. About 300 feet; latterly I have put them in at every 200 feet.

Q. Have you been through the drains?—A. Yes; through the whole of those which are large enough.

Q. What is about the temperature?—A. I never tried; but it is very hot and stifling down below.

By the CHAIRMAN—Is the Fort drainage complete at present?—A. No, only a portion of it is complete; the most expensive and difficult portion—the main line, or backbone of the system—is complete.

Q. What remains to be done then?—A. There are sewers to be made in Cowasjee Patell Street, Parsee Borah Bazaar Street, Moody Khana Street, Rampart Row, Meadow Street, Apollo Gate, and Forbes Street.

Q. And that will complete the system?—A. Yes, that will complete the main lines, and the rest will be drained by earthenware pipe drains. There are sewers completed and in use in Church Gate Street, Elphinstone Circle, Bazaar Gate Street, Hornby Row, and the eastern Boulevard. In fact, we have a sewer running round the eastern Boulevard across Bazaar Gate Street to Hornby Row, and so to Church Gate Street.

Colonel TREVOR—You have done the greater portion of the northern half of the Fort?—A. We have done three out of six of the main lines.

The CHAIRMAN—When do you expect that the whole scheme will be completed?—A. The works are now stopped; no orders have been received to go on with the remaining portion.

Colonel KENDALL—What is the explanation of that?—A. The Commissioner has given no orders.

Colonel TREVOR—There is a special sum of 2½ lakhs assigned for drainage which is not applicable for Municipal purposes.

Mr. THWAITES—Perhaps the Commissioner can answer that question better.

The CHAIRMAN—What is the arrangement for draining Colaba?—A. There are surface drains which run right and left into the harbour and Back Bay. There is no regular system of drainage at Colaba; it is very similar to the native town.

Colonel KENDALL—Are there any underground drains at all?—A. I think not; the ground is nearly all rock, which would prevent the drains being made except at very great expense.

By the CHAIRMAN—Well, then, I suppose the rest of the island is left to natural drainage?—A. Quite so.

Q. The western and north western districts of the island, Sion, Mahim, Worlee?—A. There are sluices at Love Grove, Worlee, Sewree, Dharavie, and Sion. They are almost exclusively used for monsoon water. There is not sufficient sullage water to flow into them; it never reaches them; it is all evaporated or absorbed.

Q. As the matter stands at present, there are no drains in Bombay for carrying away the whole of the night soil?—A. No, excepting the new drains which have been constructed in Camateepoora and the Fort. They are designed to carry away the night soil when it can find its way into them.

Colonel TREVOR—Are there many house connections in the Fort?—A. Yes; in Bazaar Gate Street and Church Gate Street, a great number of the houses have small gullies or drains which run between them. In some cases there are small drains underneath the houses; these have all been connected with our brick sewers by means of earthenware pipes.

By Colonel TREVOR—The earthenware pipes are not laid into the houses so as to serve for carrying off stuff from water-closets?—A. No; they are connected with the drains which come from the houses. They are only laid up to the edge of the houses, to the boundaries of the properties.

Q. In these open gullies?—A. Yes.

Dr. HUNTER—The houses in Elphinstone Circle have drains?—A. Yes; they are connected with the sewer which passes round the Circle; they are all connected.

The CHAIRMAN—Then at present the arrangement for carrying off the night soil in Bombay devolves entirely on the Health Department?—A. Entirely; except there are any works to be constructed, which then come under the Engineer's Department.

Colonel KENDALL—Do the Health Department tell you what drains they want, or do you suggest what drains ought to be constructed?—A. If the Health Officer thought a drain was necessary he would say so to the Commissioner, who would issue his orders to the Executive Engineer, and it would be constructed, or not, as the case might be.

Dr. HUNTER—Has that ever occurred?—A. It has. The Health Officer has complained that in certain districts sewers are required. The only difficulty I believe has been as to funds.

By the CHAIRMAN—Is any record kept at the Love Grove sluices of the quantity of sewage which is pumped out there in a day?—A. No; but it is known how long the engines have been at work, and the quantity could be ascertained approximately.

Q. Will you be good enough to get that calculation for us as to how much is discharged every day, taking the different parts of the year, and taking intervals of two months, just to show what passes through in the dry weather, and what passes through in the monsoon?—A. I could not give you that at once as to the other portions of the year.

Q. Don't you keep any record at all?—A. Yes; of the time the engines are worked, the stoppages, and so on.

Colonel KENDALL—You keep the number of strokes, &c.?—A. Yes; in that way it might be calculated. The record will give the number of strokes, and we know the diameter of the pumps.

Colonel TREVOR—The whole of it does not pass through the pump?—A. No; if there is a stoppage, or if the supply exceeds the pumping power.

Colonel KENDALL—What is the state of the low level drain as compared with low water?—A. The slope is 3 feet per mile, and the invert at the end is about two feet below low water extraordinary spring tides.

By the CHAIRMAN—At the Love Grove sluices, what is the arrangement for passing the sewage into the sea; how far is it carried out?—A. It is carried out as far as the coast line. The open main drain runs up to the Love Grove sluice house, where six sluices (which are opened as often as the tide will admit) discharges the water and sewage into an open cut which runs into the sea.

Q. At all states of the tide?—A. No; if the tide is high and the levels will not admit of the sewage passing out, the gates are kept closed. There is a staff of men who open and close the gates according to the state of the tide.

By Dr. HUNTER—In the monsoon and the high winds that blow at that season, don't you find it more difficult than in the dry season?—A. At high water they are covered, so that the wind will not affect them. During the monsoon the whole of the rain water from the town and flats has to be discharged there, and the engines are not worked then.

By the CHAIRMAN—After the sewage has been pumped up it passes into the sea by an open canal?—A. No; by a closed channel.

Q. What then is the open channel which we see at Love Grove?—A. It is a communication between the main drain and the sea, where the sluices deliver the sewage. The sewage which is pumped up is sent into a covered drain that runs parallel with the open channel, and is discharged at the end into the sea.

By Colonel KENDALL—At what level does this run, or where is the mouth of this covered drain?—A. It is at a low level; it is several feet below high water.

Q. How many hours in such tide will it discharge?—A. We can discharge it at any time by pumping. It is lifted from the bottom of the low level masonry drain and sent into this covered channel, and then discharged into the sea.

By the CHAIRMAN—What is the horse power of the engines employed at this pumping station?—A. I think about 75-horse power, speaking roughly from memory. There are two separate engines there.

DR. LUMSDAINE.

The CHAIRMAN—Dr. Lumsdaine, will you be good enough to explain to the Commission the system of the removal of the night soil in Bombay?

Dr. LUMSDAINE—It is removed by hand. At certain points throughout the town there are stations and iron cylinder carts. Upon these points the halalcores work, and as the carts are filled at the stations they go off to the main depot at Boree Bunder, where there are two receiving tanks. These tanks have a discharge pipe that delivers at Carnac Bunder. The carts being cylinders and practically air-tight are removed from the respective stations as fast as they are filled. Formerly, there were wooden carts, and when these were filled they had to remain all day at the stations for removal at night. Now that we have the air-tight cylinder carts the work commences at 3 A.M., and is generally over by 10 o'clock. For the Fort there is a pipe with a discharge at Moody Bay. There is a large necessary at Sonapoor which is connected with the Sonapoor drain and discharges into Back Bay. There is also a latrine at Camateepoora which is now connected with the new drain in Cursetjee Sooklajee Street, and discharges into the main drain.

By Dr. HUNTER—The night soil is carried in baskets from the several houses to these depots in which the carts are situated?—A. Yes.

Q. And the contents are put into the carts and conveyed to the main depot?—A. Yes.

Q. What is the radius over which the halalcores work to each branch depot?—A. Formerly there was only one depot at Chinch Bunder, but now we have nine, and if you take them as centres you might draw 1 mile circles which would intercept each other. The radius would be about half a mile.

Q. Urine and much excreta drain into the gullies, do they not?—A. Yes; all water used for ablution and other purposes gets into the surface drains. In most of the privies there are baskets, which are just strainers, so that the liquid sewage finds its way into the drains.

By the CHAIRMAN—Is the night soil from Colaba taken to the Fort, or is there halalcore service at Colaba?—A. There is halalcore service at Colaba, but not a depot with discharge pipes. It is taken out as far as possible.

Dr. HUNTER—It is the same there as at Malabar Hill, is it not?

Dr. LUMSDAINE—We have no halalcore service for Malabar Hill.

By Dr. HUNTER—But it is taken in baskets to the sea shore to be washed away by the tide?—A. Yes.

By the CHAIRMAN—I suppose the same remark applies to the other outlying parts of the Island?—A. It does,—it applies to Parell, Mahim, Sion, Sewree, and Chinchpoogly.

Q. Do you consider this system of removing the night-soil satisfactory?—A. I do, if it were more complete.

Q. If you had a larger staff of halalcores?—A. Yes.

Q. Do you consider the system more satisfactory than carrying the night-soil through drains?—A. Yes; I think it is.

Q. Will you give us your reason for that?—A. Well, I am no advocate for sewage being passed into drains.

Q. What is your objection?—A. Gases generate, and I don't know how you are to get rid of them.

Dr. HUNTER—If excreta were well diluted, so that there were only 2 or 3 lbs. in a ton of sewage, do you think that would be a very bad way of carrying off sewage from a large town like Bombay, where the levels are so bad.

Dr. LUMSDAINE—The only objection I have in a sanitary point of view is the difficulty of getting rid of the gases that are generated in the sewers. Until these can be controlled, I would keep the present system, and exclude the night-soil.

Dr. HUNTER—Your system necessitates the sewage being put into tanks and then the harbour.

Dr. LUMSDAINE—I don't know anywhere else it is to go.

Dr. HUNTER—But your system involves that.

Dr. LUMSDAINE—Yes, so long as the harbour is the outfall.

The CHAIRMAN—Having regard to the circumstance that night-soil must be disposed of in some way, do you think there is any strong objection to night-soil being discharged into the harbour ?

Dr. LUMSDAINE—It would be better if it were not discharged there. If tidal influence is to remove it, I would rather have that influence on an open coast line than in a land-locked harbour.

By Colonel TREVOR—Have you heard of any evils arising from the discharge of most of the sewage into the harbour ?—A. Not beyond complaints from various people of the discharge pipe at Carnac Bunder. We cannot always hit the tide, and the sewage sometimes goes where it should not go—sometimes goes up the harbour instead of down, and gets into the Nicol Basin and other places.

By the CHAIRMAN—Has any better plan for disposing of night-soil occurred to you than that of pouring it into the harbour ?—A. Well, I have not entered into that part of the question. It is a question of levels, a question for engineering.

Q. Do you think the discharge of night-soil into the harbour is injurious to the health of the crews of the shipping in the harbour ?—A. I do not know that it is.

Q. Beyond the unpleasantness which must attend the discharge of night-soil wherever you put it, do you think there is any real objection to the discharge of night soil into the harbour ?—A. I don't know sufficiently about the current to speak with any certainty about it, but to the best of my own knowledge I am aware of no objection if discharged when the tide is going out.

Q. I suppose you have been at Carnac Bunder at the time when the sewage is discharged ?—A. Yes, I have.

Q. And there is no doubt considerable smell from it at the time ?—A. Yes; but not more than there would necessarily be wherever it was put.

The CHAIRMAN—Is it not the fact that almost immediately on the commencement of the discharge of night-soil through the pipe into the harbour, large flocks of marine birds settle on it and dispose of a large quantity of it almost at once ?

Dr. LUMSDAINE—I have not observed that.

The CHAIRMAN—I have seen them coming down, gulls and other marine birds, in thousands. You see the flocks coming as soon as the pipes are opened and acting as scavengers for the Municipality of Bombay.

Dr. HUNTER—Very often I believe the shore in the neighbourhood of Carnac Bunder is partly covered by night-soil.

Dr. LUMSDAINE—The pipe has been carried to the end of Carnac Bunder.

Dr. HUNTER—Is not the air at Carnac Bunder always more or less fouled by the exhalations from the night-soil ?

Dr. LUMSDAINE—Not more so than in the native town.

The CHAIRMAN—Don't you think there is a much purer atmosphere at the end of Carnac Bunder than there is in any street in the native town ?—A. I do.

The CHAIRMAN—Do you know what quantity of night-soil you collect per day ?

Dr. LUMSDAINE—We collect more than the tanks will hold. We want receiving tanks of a greater capacity.

Colonel TREVOR—What proportion of the population do you think you serve ?

Dr. LUMSDAINE—We serve 14,738 houses, and there are calculated to be 22,000 houses in Bombay, I think.

Colonel TREVOR—Then you serve about two-thirds, or a little more; but I suppose these are the largest houses ?

Dr. LUMSDAINE—Yes; they are mostly in the native town.

Colonel TREVOR—Did you ever calculate the quantity of night-soil that you discharge in a day ?

Dr. LUMSDAINE—The daily average is about a hundred carts, and each cart contains 1,792 lbs.

The CHAIRMAN—That is 16 hundredweight in each, or 80 tons in all.

By Colonel TREVOR—Do you know the experiments Dr. Hewlett made to ascertain what the quantity of night-soil was per head of the population per day ?—A. No.

Q. This is not all solid matter. You take a good deal of water ?—A. There is very little solid matter; I should think you might say 2½ ounces per head.

Q. Is that what you consider the production per head of all the people of the island, or of only those you serve ?—A. That is what I think each man averages per day.

Colonel TREVOR—That is rather less than Baron Liebig's estimate.

By the CHAIRMAN—Do you think your halalcores clear off pretty nearly the whole of the night-soil that is to be found in the houses?—A. I think they do. I think they carry off the greater part of it. A good deal of it from the defective necessaries of course finds its way into the gullies, and so into the drains.

By Colonel TREVOR—What is the usual plan adopted for its collection in the necessaries before the halalcores take it away?—A. Some of them have iron receptacles, but in the majority of places there are just baskets, like the baskets coolies have, and the water passes through these and carries away a great portion of the fœces, which are generally in a liquid state.

Q. Do you enforce any rules with regard to the manner in which the night-soil is to be collected in the houses you serve?—A. Each halalcore has to make so many trips a day according to the distance that he is from the station to which he works.

Q. I do not mean that. I mean do you enforce any rules to be observed in the necessaries for the convenience of the men who take the night-soil away?—A. No.

Q. But would that not be a necessary condition?—A. We have no power. A man can do as he likes in his own house. All we can do is to remove all that is there.

Q. But you have no means of knowing that you remove it all?—A. I suppose it all does find its way there from the houses.

By Colonel TREVOR—Has any attempt been made to have iron pots used in preference to baskets?—A. On asking them to do it, a great many do so; but you cannot force them to do it.

By the CHAIRMAN—It would be a very good thing, would it not? It is impossible to suppose that the present system is as good as drainage if you are not sure you get all the night-soil?—A. I think we get the greater part of it.

Q. Not the whole?—A. No.

By Colonel TREVOR—Are any objections raised to iron pots in the necessaries?—A. No; those who use them prefer them to the baskets.

Q. So that it is just merely a matter of expense in introducing them?—A. Yes.

Q. Do you find the houses kept cleaner where these iron tanks are used?—A. Oh, yes.

Q. Has any pressure been put on the people to get these iron tanks introduced?—A. We cannot well compel them except by indirect pressure. There is no law to compel them to use them.

By the CHAIRMAN—How many public necessaries have you got in Bombay?—A. Fourteen.

Q. Can you tell us where they are?—A. There are four at Colaba, one at Moody Bay, one at Sonapoor, two at Camateepoora, two at Parell, two at Khara Talao, and two at Carnac Bunder.

Q. I need scarcely ask you whether you consider that a very small number?—A. I do.

Q. There ought to be many more?—A. Yes.

Q. Are they largely resorted to?—A. Very largely.

Q. Are they raised from the ground so that the carts can go under them?—A. No; unfortunately the carts were made after the latrines were erected.

Q. Do you think it would be an advantage to have them so built that the carts would go under them?—A. Yes; and they are to be raised with that object.

Q. Have you used the dry earth system at all?—A. No.

Q. Do you think it could be introduced into Bombay?—A. No.

Q. What is your objection to the dry earth system?—A. I don't think it would act. You would have to keep it dry until you could remove it from the island; and during the rainy months you could not do so. There would be a difficulty as to distribution, and a greater difficulty in enforcing its use.

Q. And there is an objection with reference to the habits of the people?—A. Yes; I think it is open to every objection.

By Dr. HUNTER—There is an objection on account of the habit of the natives who use a large quantity of water at every call of nature. You could not get rid of that habit. Don't you think there are these two objections—the heavy rain fall during the monsoon, and the fact that the natives of this country use water every time they go to stool?

Dr. LUMSDAINE—I think a greater objection is the want of the earth. You have not got it.

Dr. HUNTER—You can get it by railway. I am not speaking of the expense, but the value of certain facts which are antagonistic to the introduction of the dry earth system in this country. With

reference to the utilization of sewage, have you formed any opinion as to the advisability or inadvisability of that in this country ?

Dr. LUMSDAINE—Yes ; I am in favour of it.

Dr. HUNTER—Do you think there would be any objection to using sewage on the land in this country ?

Dr. LUMSDAINE—No ; I don't think so.

Dr. HUNTER—Would not the rapid evaporation of the water leaving the excreta to dry and be reduced to a pulverised powder, which would be blown about by the strong wind, such as we have in the neighbourhood of the sea, be an objection to this system ?

Dr. LUMSDAINE—I think it depends on the manner in which it is carried out.

Dr. HUNTER—The soil becomes saturated with excreta and the evaporation is exceedingly rapid.

Dr. LUMSDAINE—I think we nearly have that in Bombay already.

Dr. HUNTER—Do you think it would be increased by putting sewage on the soil ?

Dr. LUMSDAINE—I do not think there would be any harm in it.

Dr. HUNTER—Have you read the summary of the proceedings and reports of the International Sanitary Conference of 1866, compiled by Dr. Leith ? There are some very strong facts there.

Dr. LUMSDAINE—Yes.

Dr. HUNTER—And have you read a paper lately by Dr. Rawlinson, of Oxford, on the earth system, in which he points out great sanitary objections to it? At pages 32 and 33 of Dr. Leith's abstract of the Sanitary Conference there are some very strong remarks. Then there is the opinion of Dr. Pettenkofer, which agrees with that of Dr. Snow, Dr. Pellarin, and Dr. Budd. Dr. Pettenkofer, it is said in the abstract, "considers it as demonstrated by his observations that in an epidemic of cholera the earth itself of the place where the disease prevails has a great share in its development by the emanations that escape from it. It is thus that he admits that a porous soil, easily permeable to water and air, and charged with excrementitious matters (consequently an alluvial soil, a marshy soil), impregnated with choleraic dejections, becomes at first a receptacle, then, according to circumstances, a source, more or less active, from which the principle of the disease issues, the activity depending on the subsoil waters, and being therefore dependent on alternations, more or less considerable, of the humidity of the superficial layer of soil. This aptness of the soil for receiving the principle of cholera will explain the tenacity with which the disease clings to certain places, and even its recurrence, apparently spontaneous, after having more or less completely disappeared. It is in India, and particularly in the districts where cholera is endemic, that the truth of this doctrine will have to be determined. Perhaps it will explain the endemicity. It is a fact well known in India, and of which we find examples in books, that the ground on which soldiers or other affected with cholera have encamped can transmit the disease." The conclusion of the Conference in regard to this was—"That it seems to result from certain facts that the ground of a place once impregnated with choleraic matters can for a considerable time retain the power of giving off the principle of the disease and of keeping up an epidemic, or even of reproducing it when it has been extinct." That is very strong language against the utilization of sewage in the neighbourhood of towns ; and it is also notorious that in cases where the sewage is utilized for agricultural purposes they don't allow it within a certain distance, 500 or 1,000 yards, of military cantonments ; and there is no doubt, I think, so far as our knowledge of the nature of cholera at present goes, that it acts like fermentation and goes on from time to time developing itself. It is a well known fact that in India the ground on which soldiers or others affected with cholera have encamped can transmit the disease if you have cholera excreta thrown on the land, which through evaporation becomes a dry dust blown by the breeze all over the land. If you can carry it away to districts where there are few inhabitants, then I would not object ; but I am speaking of utilizing the sewage in the vicinity of large, densely-populated towns.

By the CHAIRMAN—Do you think, Dr. Lumsdaine, apart from the financial question—the return you might get by selling it as manure—that the utilization of sewage in India is more desirable than carrying it off by water in a town like Bombay surrounded by the sea ?—A. I can only speak on that point so far as it has been tried. It has been tried to a limited extent here, and if all our waste lands were brought into a state like that where it has been tried, I think it would be a benefit to us.

Q. You refer to the experiment on the land at the side of the main drain ?—A. Yes. I think if all our waste lands were like that it would be better for us than it is now.

Q. Do you think any objections would arise on the part of the native cultivator against using the sewage?—A. No.

Q. Or on the part of the native consumers to eating vegetables grown from it.—A. None whatever.

Q. There would be no religious or caste objections?—A. I don't think so. There might be some shadow of a scruple at first.

Q. Do you know whether the cultivators in the neighbourhood of the main drain have been stimulated by Mr. Crawford's success to use the sewage on their lands?—A. I do not.

Q. Would you be in favour of employing the sewage as manure within the island itself?—A. Yes.

Q. In Bombay itself?—A. On the island.

Q. And could that be done without injury to the people there?—A. I think so.

By Colonel KENDALL—You have said you have not sufficient halalcores to do the work properly. How is that? Can you not find men for halalcores?—A. There are plenty of men; we only want the money.

Q. There would be no lack of men?—A. No. We have had to discharge a number of men lately.

By the CHAIRMAN—Do you find any difficulty in collecting what is called the halalcore cess?—A. I have nothing to do with that.

Q. Do you know, as a matter of fact, whether the halalcore cess yields enough to pay the wages of the halalcores and the supplies that are necessary for that department?—A. It does not.

Colonel TREVOR—But will it not do so after the reductions you have made lately?

Dr. LUMSDAINE—It will not.

The CHAIRMAN—Do you think it better to have a separate halalcore cess for halalcore service, or do you think it preferable to pay the expense of the whole scavenging from the general rates?

Dr. LUMSDAINE—I can hardly give an opinion upon that, but I know that the cess falls short of the cost.

The CHAIRMAN—Can you say whether the native community generally are satisfied with the working of the halalcore system; or do they complain of it?

Dr. LUMSDAINE—I have had nine complaints since 1st January. These are complaints of halalcores' neglect.

Dr. HUNTER—These halalcores are the most troublesome class of working people in India, I suppose. I speak from experience in the Jamsetjee Hospital. Scarcely a day passes without complaint there.

The CHAIRMAN—How has this demand for an entirely new system of drainage arisen—from the representations of the Health Department, or from the native community, or from other sources?

Dr. LUMSDAINE—I fancy the expression of the want has been accumulating for many years before my time.

Colonel KENDALL—What urgent necessity is there for an improved drainage? We gathered from some of your earlier answers that you believed more in the halalcore system than any system of drainage for Bombay.

Dr. LUMSDAINE—We want surface drainage.

Colonel KENDALL—Do you think that what is wanted is surface drainage for the water during the monsoon?

Dr. LUMSDAINE—Yes; and drainage for house waters.

Dr. HUNTER—In consequence of the habits of the natives a great deal of the fœces must be washed away in the gullies?

Dr. LUMSDAINE—A very great deal.

Dr. HUNTER—So that only a small quantity is left for the halalcores, and the surface drains are really sewage drains, having a large quantity of washed away excreta.

The CHAIRMAN—Is it your opinion that with an improved system of surface drainage and a proper development of the halalcore system, new drainage for the purpose of carrying off the night-soil as well as the sewage of the town would be unnecessary?

Dr. LUMSDAINE—Well, I am opposed to sewage—by sewage I mean night-soil—getting into drains.

The CHAIRMAN—Then I presume it is your opinion that an improved surface drainage and an improved halalcore system would do away with the necessity of drainage for carrying away the night-soil?

Dr. LUMSDAINE—Yes, until the sewer gases are brought under control.

EIGHTH DAY, SATURDAY, APRIL 24.

The following Commissioners were present :—

ANDREW R. SCOBLE, Esquire, *Chairman.*
Colonel KENDALL, R.E. | Lieut.-Col. TREVOR, R.E. | Dr. HUNTER,
Dr. LYON, *Secretary.*

The Commission resumed at 2 o'clock on Saturday, in the Durbar Room, Town Hall.

MR. RUSSEL AITKEN :—

Mr. AITKEN—I propose to begin by giving a short outline of the present drainage of the native town, in describing which Mr. Thwaites made some slight mistakes about matters of detail. Then I would consider whether it is desirable to admit night-soil into any of the new drains. The third point would be, what is the best means of disposing of the sewage water. Next I would make some remarks on Mr. Rawlinson's proposals as worked out by Captain Tulloch; and after that I will explain my drainage scheme and reply to objections which have been urged against its adoption. I have prepared a plan showing the present drainage of the native town.

The CHAIRMAN—Will you then first of all give us your explanation of the present system of drainage in Bombay?

Mr. AITKEN—As to Colaba there are no drains, excepting a very few trifling open drains and one or two covered ones. The water generally finds its way to the harbour and Back Bay, the ridge sloping from the centre. The privies and mangrove bushes in Back Bay to the windward of the barracks are very objectionable. The Esplanade is drained chiefly by the absorbent power of the subsoil, which being clean, sharp sand, the rainfall soaks into it and thence finds its way into the sea. Part of the water also runs over the surface of the ground and finds an outlet first through the new Fort system of sewers, where a connection was made for it near the Chief Engineer's office. There is a large drain near the New Market at Boree Bunder; and at the Money School there is a covered drain, which takes part of the Esplanade water to the drains in Dhobie Talao. In the fair season all waste water from the houses at the Marine Lines, &c., goes into the ground. The old system of drains in the Fort may be briefly described as long square cesspools eighteen inches to two feet square covered with flat stones. To save excavation and trouble these drains were made as near the surface as possible, and in many cases have little or no fall, so that they require to be frequently cleaned out, as the night-soil, which finds its way into them, is not carried off, and decomposes into a black putrid mass, which requires to be periodically cleaned out. The cost of the municipal drain cleaning establishment is one lakh and a half a year. There are two outlets for the Fort sewers into the Dockyard basin, which cause great nuisance: these two drains should at once be intercepted by constructing a new sewer up Apollo Street. The new system of Fort sewage is being constructed on the combined system, so as to take away all rain and sewage water and night-soil from the houses, and is calculated to remove a rainfall of ½ of an inch per hour. This work was designed by Mr. Tracey, and was further worked out by me, as will be seen from the Municipal Commissioner's Budget for 1868, when an estimate amounting to Rs. 4,20,000 was sanctioned. These sewers work very well both in fair weather and monsoon; there is no deposit of night-soil, but only a little sand and grit, which is quite clean.

The CHAIRMAN—How much has been spent on the Fort sewerage up to this time?

Mr. AITKEN—About a lakh, I should think.

The CHAIRMAN—Not more than a lakh?

Mr. AITKEN—About a lakh or a lakh and a half. The larger portion of the work has still to be done.

Colonel TREVOR—It is getting on very slowly.

Mr. AITKEN—The disadvantage, when I was in charge, was the want of bricks. Now we have got bricks, but no orders have been given for their completion. I think the idea of night-soil getting deposited in the new sewers in the Fort is quite chimerical. Night-soil is always lighter than water and floats on the surface—if you go down into the sewers you can see that.

The CHAIRMAN—Before you leave that, can you say at what point between high and low tide this Fort sewer discharges into the sea?

Mr. AITKEN—About four feet from high water, the line of the reclamation is about 50 feet beyond the line of the present outlet, but when the permanent reclamation is built the outfall will of course be properly constructed. At present it is merely temporary. I never experienced any smell, though I have stood over the outfall at all hours. Of course there is a slight smell, but nothing to complain of. If it had been a nuisance the occupants of the Mint would have complained. I never heard of any complaint from them, and do not think that any have been received by the Commissioner.

Colonel KENDALL—Is it an open duct from the mouth of the sewer to the low water mark?

Mr. AITKEN—The sewage comes to the edge of the wall and then falls over it.

Colonel KENDALL—It is left open?

Mr. AITKEN—Yes. The sewage pours down in a cascade. Colonel Maxwell once stopped our works, but it was arranged that we should go on. There is only a temporary outfall at present. There is no difference of opinion between any of us as to the drainage of Colaba, of the Esplanade, or of the Fort. It is agreed that the Fort drainage shall be carried out on the principle of combining the surface water and sewage, the Esplanade will be drained by open and covered drains, and the greater part of the rainfall will find its way through the sandstone of which it is composed. But the great problem to be solved is the drainage of the native town, where three-fourths of the inhabitants, or say 600,000 of the population, reside. There is a very common impression abroad with regard to the native town, and that is, that a large portion of it slopes towards and is drained into the harbour, but that is quite a mistake. Only a very small portion of it in the neighbourhood of Dongery Coolee Street and Shamjee Hassajee Street drains into the Harbour. A part of the native town drains into Back Bay, but by far the greater portion of it drains towards the Flats. The drains in the native town being similar to those in the Fort, are in a very unsatisfactory state, as not being properly constructed they require to be frequently cleaned out. The whole of the old native town, between the Parell Road and the Harbour, is well supplied with drains, such as they are. Parts also of Dhobie Talao and Bholeshwur near the Temple are also well drained. But the oarts, such as Kalbadavie, Funnuswaree, the houses along the Breach Candy Road, the Girgaum Road, Girgaum, Coobarwadda, &c., have no covered drains; the ground being sand absorbs the drainage, which filters slowly back into the wells which abound in this neighbourhood. This may in some measure account for the excessive amount of cholera in this quarter. The sewage finds its way into the large main drain and thence through the new low level sewer across the Flats to the Love-grove pumps, where it is pumped up by two engines of a nominal power of 12-horse power each, or 24 collectively, and not 75 as given by Mr. Thwaites. The total amount pumped during the dry season amounts to nearly 4½ or 5 million gallons per day. The pumps are not now worked up to their full power, consequently there is a great nuisance on the Flats. Last year the large open main drain was kept dry and the Health Department cleaned it out. The pumping power appears this year to have broken down. The engines work up to about 21-horse power and consume 15 lbs. of coal per horse power per hour. New engines and boilers are on their road out from England.

Colonel KENDALL—Are any of these drains egg-shaped?

Mr. AITKEN—No; the main drain is arched with a flat bottom and straight sides. The Bholeshwur one has straight side walls and an arch over the top; and so has the Oomercarry Road Sewer. As for the other drains they have straight sides, generally flat bottoms, and slab-stone covers. Many of the streets have drains up each side; others have a drain down the centre. As to the advisability of admitting night-soil into any system of sewers, the Health Officer's Report for 1866 shows that at the commencement of that year there were but 40 carts of night-soil removed to Chinch Bunder, at the end of the year, 111 carts were emptied there, in addition to which there were 4 private night-soil

carts. Dr. Lumsdaine, by adopting the new pattern of cart, and by taking other means, collects as much as would fill 150 of the old night-soil carts. Is that correct?

Dr. LUMSDAINE—I think not 150 but 180.

Mr. AITKEN—So that four or four and a half times as much night-soil is now removed as was formerly the case before the Act of 1865 came into force. Notwithstanding this great increase, my opinion is, that from the habits of the people 50 per cent. of the night-soil, together with all the urine as well as the sullage water from the houses, now finds its way into the drains. Any evils which may be anticipated from admitting the remaining 50 per cent. of night-soil are, in my opinion, purely imaginary, and may, I think, be disregarded, the more especially as the drains it will be admitted into will be so constructed as to run both night-soil and water off as soon as it reaches the drain, and not allow it to stagnate and rot in the drains, as it now does. I think night-soil may without danger be admitted into the drains, as it can remain there but a few hours. Even supposing you could remove the whole of the night-soil by hand, it would be better to allow it to go into drains, because at present it remains in the city at least fifteen hours, whereas if it be put into drains it would remain but three or four hours. The cost of removing even the small portion of the night-soil before referred to was in 1867 not less than Rs. 5,67,740. Dr. Lumsdaine has reduced the expenditure to about four lakhs. But in 1867 the loss on this account was Rs. 4,40,000, which had to be taken from other funds to supply the deficiency caused by the halalcore cess collections not meeting the expenditure of that department. This annual expenditure is the interest of a very large capital indeed. Then there is the danger of a strike amongst the halalcores. There has been one already, and it was only by the energetic way in which the Municipal Commissioner took up the matter that disease was prevented. Now I do not think it right that the town should be liable to be decimated because a portion of the lowest caste choose to strike. I think it would be better to trust to machinery than to these bunghies. The pay of these men is also very great. I think the present service, although it is as well worked as such a system can be, is very inefficient, and that a great deal of night-soil goes into the drains. In my main drainage report I have given my reasons why the dry earth system cannot be adopted in Bombay; and in my reply to Dr. Hewlett's remarks on my drainage scheme, I have shown the impracticability of the Liernur system. If it be conceded that night-soil is to be admitted into the drains, the question of the disposal of the sewage is the next point. There are two modes of disposing of the sewage: the first is by getting rid of it by throwing it into the sea and allowing it to be absorbed and destroyed by it; and the next is to utilize it on land. Let us suppose we can utilize it, the next question is—How much land will be required? In England it is found that sewage is most favourably utilized when an acre of land is used for every 100 persons. Here is a very interesting paper by Mr. Baldwin Latham with regard to the proceedings at Croydon, where the sewage has been most successfully utilized, and as it gives the result of experience it may be depended upon. He gives us some data to go upon as to the quantity of land required to purify sewage. He says—"It may be taken as nearly correct, that the dry weather flow of the sewage of London is about equal to the supply of water, which at 30 gallons per head per day of the population would give 4,888 tons per annum, or, according to the previous calculation, an acre of ground will require the sewage of 100 persons in order to grow 40 tons of grass. This calculation entirely accords with our experience at Croydon, and it also agrees with the experiments made by the Sewage Commission, who arrived at the conclusion that 5,000 tons of sewage per annum is the right amount to apply in order to get the greatest results." It stands to reason that a plant cannot absorb more than a certain amount of nourishment, and if we apply to Bombay the rule that an acre of land is required for every 100 persons, then for a million persons we will require no less than 10,000 acres, or nearly 15 square miles of ground. Mr. Rawlinson's idea of having only 800 acres is quite preposterous. More than ten times that area will be required to purify the sewage of a population of one million. One hundred persons with 30 gallons a head per day throughout the year would give a depth of 4 feet of sewage all over. This is more than enough to irrigate a rice crop. If we take 20 gallons per head, 7,700 acres would be required, so that 12 square miles would be required to utilize the sewage of 1,000,000 persons, that is, if the plants could absorb the impurities. Captain Tulloch, at page 15 of his report, cuts out two paragraphs from my remarks on Mr. Rawlinson's scheme, which somewhat misrepresents my meaning. What I endeavoured to say as clearly as possible was, that in order to deodorize a certain amount of sewage, you require a certain quantity of land; and I said that, unless you provide this amount of land, the water would pass off in as foul a state as it was put on. Captain Tulloch, however, to suit his argument, leaves out all the intermediate part of my paragraph. The paragraph is so mutilated that it

makes my meaning quite unintelligible. I say then, before you can utilize sewage, you must put it upon an amount of land which experience has shown is required to perform the cleansing operation. You can no more make a plant take up more sewage matter than you can make a man take more food than is good for him without injuring him. The question then is, where is the land? Salt land cannot be turned into gardens, and there is but little sweet ground. In Salsette the sweet batty ground is much cut up by rocky ridges, so that there it would be difficult to apply the sewage without much pumping and great expense in feeds and ducts. But, again, if for the sake of argument we suppose that all the sewage water is used for gardening purposes, then we find that gardens in Bombay with a porous subsoil require 5,000 gallons per acre per day, so that we would require 4,000 acres to utilize the sewage of 1,000,000 inhabitants, or not less than six square miles. I have given my reasons for saying that irrigating Italian ryegrass will not pay, and I adhere to these reasons. Captain Tulloch, in his reply to my remarks, attempts to make out that I was very inconsistent, because I had said the utilization of sewage as proposed by Captain Tulloch would not pay, whereas in my water works extension report I had said that water applied without pumping would pay. Now, I think, the two cases are very different. If Captain Tulloch will go in for irrigation for rice, grass, and so on, he should not have taken the figures I gave for the water supplied in Bombay, but the figures at page 19. For 40,000,000 gallons a day I only calculated that you would get Rs. 50,000 per annum, so that in Bombay for 20,000,000, or only half that amount, you would only get Rs. 25,000. That is for pucka irrigational purposes, but in my remarks on Mr. Rawlinson's report I have given Rs. 33,000 as the probable return to be obtained, so that far from being unfair to Captain Tulloch I have credited him with more than he can claim under my report. I don't suppose Captain Tulloch proposes to take his pipes through Girgaum, Khetwady, Sewree, and so on, and supply these places with sewage; if he did, his expenditure would be enormously increased. But the Vehar pipes are laid over all the island, and if an extra supply of water were brought to the town it could be supplied for pleasure-grounds and fountains, for which sewage would not be taken. I don't think, therefore, that Captain Tulloch has made a fair comparison, and I say that there is not sufficient land near Bombay for the utilization of the sewage, and that it will not pay to go to the expense of pumping sewage for new irrigational purposes. The Commission is very well aware there was a considerable amount of waste water from Lake Vehar which passes the village of Marole. A cultivator there put up Persian wheels to draw the water, the supply of which was practically unlimited, and had a lift of only 6 or 8 feet. The trials went on for several years, but as the cultivator was obliged to keep a pair of bullocks to take the vegetables to the market the expense of keeping these bullocks was sufficient to prevent any profit being got, and so the venture was given up. It would be very objectionable to allow sewage to flow on the ground in the island, unless some method were adopted to prevent waste and consequent nuisance. I believe that in several of the towns in Scinde where an unlimited quantity of water was supplied, by allowing it to run on to the ground, the result was that there was a great deal of fever and it had to be given up. The sewage ought to be kept so low, that it will be required to be lifted by Persian wheels so as to prevent its being wasted. If you give an unlimited quantity it would become a nuisance. Captain Tulloch rather twitted me because I said that in Birmingham the result had hitherto been a failure.

The CHAIRMAN—I don't think you need go into these small points.

Colonel KENDALL—We want you to explain your scheme, not to remark on these small matters.

The CHAIRMAN—We will have to sit much longer than will be convenient for any of us if you go into these matters. If you confine yourself to the general grounds of opposition it will be better for all of us.

Mr. AITKEN—This is a most important matter. I know that the Birmingham people have been forced into utilization and would be gladly quit of it if they could. The cause of the failure has been that they put too much sewage on to the lands, or the very same thing happened as will happen in Bombay if Mr. Rawlinson's recommendation be carried out. Utilization has not been carried out in England except to prevent the fouling of rivers. Utilizing the sewage of London has been proposed for the last 30 years, but although numerous trials have been made and much money has been spent they are no nearer a solution of the question than they ever were. The next question is the separation of rain-fall from sewage. This is the main point on which the whole drainage question hinges, and it is divided into—first, the separation of fecal matter from house drainage, and second, the separation of fecal matter from house drainage and rain-fall. It has never been

proposed to separate fecal matter from house drainage, but only to separate the sewage and house drainage from the rain-fall, which in Bombay is excessive. It has often been proposed to separate rain water from sewage, so that the commercial value of the sewage may be increased; but it has never been proposed to separate sewage from rain-fall on any other ground. There are two requirements a good system of drainage should fulfil:—the first is that it should drain the subsoil, the second is that the main drains should be easy of access, so that the drains may be cleaned and inspected. The present drains are very obnoxious on this account, as the road has to be opened when the drains are being cleaned. The drains being built shallow, but little excavation is required, but if they were deep it would be very expensive to open them. The separation scheme, as proposed by Captain Tulloch, depends on hermetically sealed tubes, which working at full pressure will not only not drain the subsoil but may allow sewage to escape into the soil. Even Captain Tulloch's main sewers are too small, as the water in them will be too deep to allow people to work in them. That the subsoil should be drained is absolutely necessary, and that the system proposed by me will do so is shown from the fact that the level of the water in the Mint compound has been lowered notwithstanding that every attempt was made to make the drain water-tight. Then again I consider that if you separate the rain-fall from the sewage you must go to a very considerably greater expense for such a system than if the combined system is used. There is a large portion of the town that would require to be drained of the surface water. When a town gets densely populated it would not pay to take the water away by open surface drains; the land becomes so valuable, both for streets and traffic, that it pays to cover the surface drains. I may say that Mr. Ormiston has proposed to have open drains, but on the Elphinstone property he has covered his drains; and he is quite right, for land is there too valuable to be taken up by open drains. It may be accepted as settled that the main drains of any system of sewerage should be of such a size as will admit of men getting in to examine them, and in case of any trifling obstruction getting into them to prevent their becoming blocked up. I think the use of a 12 or 15-inch pipe, as proposed by Captain Tulloch, is very objectionable indeed. By that means his estimate has been kept down, but he proposes to use these pipes to an unheard-of extent. I never saw or read of any large town being drained on the double system. Captain Tulloch objected very strongly to my proposal for a steel drain, and I gave my reasons for proposing that, viz., the very great saving of money, when compared with any other system. There could be no saving at all if the double system of sewage be adopted, probably the reverse. I use 12-inch pipes for short lengths or for drains not exceeding 150 lineal yards or so in length only; but 3 feet 9 inch by 2 feet 6 inch sewers are used for longer lengths. The charge of inconsistency cannot therefore be sustained as the uses to which pipes are put in the two schemes are entirely different. Many thousand feet of piping are now coming out from England for the Camateepoora sewage works. I wish to state that the sample of a street in Bombay which I give in my reply to Mr. Rawlinson, was taken at random. I have brought a plan of Major Laughton, which will show the difficulty still more strongly. In Kalbadavie Cart there is no drain at all, at least the drains are so trifling that there has been no money spent on them. And I don't see very well how the surface water is to be taken away with one set of drains, and night-soil and sewage water by another.

Mr. CRAWFORD—I have, since recent works, considered that cart very well drained.

Mr. AITKEN—I do not think so—not in the monsoon—there is no surface drainage.

Mr. CRAWFORD—You designed and executed the drainage yourself, so that you are responsible for it.

Mr. AITKEN—The drains at all events are not of sufficient depth. For instance, there are two side drains, but in these carts the water finds its way very freely into the ground. Of course it is an engineering question, and a very complicated one. I have thought a great deal over it, and started with the intention of separating the rainfall from the sewage, but the difficulty was so enormous that I was obliged to give up all idea of it. The present drains are not sufficiently low to give you a sufficient fall for your side drains. If you run deep drains round Kalbadavie cart you would get sufficient fall. To the left of Parell Road, down by Kalbadavie, and a good deal of Bholeshwur, there is no system of building, and I do not quite see how that is to be drained on the separation system. As to the separation of sewage from rainfall, I have thought a great deal on the subject, and the more I think of it the less I like it. I do not propose to retain gullies. I think they are most objectionable. I have never proposed in my writings to retain gullies. But the town is now in a state of transition, and we could not go at once and tell these people that the use of gullies must be at once abandoned. I think the great object is to have some system, which will admit of transition between the two periods. A great deal of sewage finds its way into the gullies, and these gullies are a very filthy way of draining a city; it

has been given up in all the towns in Europe and will be superseded in Bombay. But as the town is in a transition state, I think that must be attended to and considered. When any man wished to connect privies with new drains, then, of course, he would be required to lay in pipes in the usual way. I am at a loss to understand why in Bombay sewage should be separated from the rainfall. In the Fort system the sewers that have been made have generally taken the place of the old drains in the centre of the streets; in Bazaar Gate Street, for instance, the old drain had to be removed or the new one could not have been laid down at all, and I say if you lay down so many pipes you will cut across the present drains so much with your connections that they will practically require to be remade. I think it is quite impossible to separate the rainfall from the sewage. I don't know whether there are any other questions you wish to ask me as to the separation of sewage from rainfall.

Colonel KENDALL—No, I have none whatever, you have expressed such strong opinions upon the subject that there is an end of the matter.

Mr. AITKEN—The scheme I have proposed is not in any way a novelty. As I said in my Report on Main Drainage, dated 21st December 1866—"In working out the detail of this system, I have carefully avoided introducing any novelties, the whole plan being based on one which has now been for some time in operation, and on the conception and working out of which the highest engineering talent of the day has been bestowed." I have followed the system which has been adopted in London. It is open to certain objections, but it is as good as any human design can be. It is not perfect I acknowledge, but the point is to steer one's way through the difficulties which continually arise. An impression seems to have got abroad that I attempt to deal with the whole of the rainfall. I think that is a very serious misapprehension. Captain Tulloch is the only one who proposes to deal with the whole rainfall of the town. He proposes to construct a main drain at a low level to be taken to Love Grove to take away the surface water. I only attempt to take sewage up to a point of such dilution that it is not more impure than what surface water running off a town inhabited by a vast number of men and animals would be. It is quite a mistake to suppose that surface water is free from impurity. In London, mixed surface water and sewage after a heavy storm was found to be more impure than sewage only—that is, in a mixture of sewage and surface water taken out of the London sewers after a heavy storm there was found more impurity than in sewage running by itself. Here is a paper by Mr. Latham, a most able engineer, where he states as follows:—"Professor Way adds—So far as London is concerned, and considering only the composition of the liquid which reaches the sewers in time of rain from the streets, it seems pretty certain that it would be as valuable in a manuring point of view as the ordinary contents of the sewers." There is a great quantity of organic matter in the surface water of a town such as Bombay, and one of the great objects of a system of sewage should be to take this impurity away. When the rainfall exceeds four inches per day, the sewage becomes so diluted that practically it may with great safety be run on to the Flats, and there allowed to mix with the other water which flows from the surrounding high ground.

Colonel KENDALL—You still adhere to all the opinions expressed in your report; there is no modification of what is described in this report.

Mr. AITKEN—There are one or two modifications.

Colonel KENDALL—Will you let us know them?

Mr. AITKEN—Formerly it was proposed to make a street from the Money School to the Null Bazaar at a cost of 5 lakhs, but that has been declared to be financially impracticable. The main sewer at Colaba was to run down the centre of the street (pointing to the plan), but it has now been altered so as to run down Shaik Memon Street and pass the new market across the Esplanade under the eastern boulevard and thence to Colaba. I took the price of Rs. 200 per lineal yard of tunnel as it was given me by the contractors who worked on the Ghaut. Messrs. Wells and Glover were consulted by the Commissioner, and the Commissioner wrote to the Government stating that he had consulted competent authorities, and that they stated that the prices in the estimates were fair. As to this section of a tunnel which is given in Captain Tulloch's paper, having been for two years doing nothing else but tunnelling, I may perhaps be allowed to differ from Captain Tulloch, who appears to know very little about such work.

The CHAIRMAN—I think that is not necessary.

Mr. AITKEN—The price which I have given is certainly a very fair one, and a very good price indeed, and there is no risk of not finding a contractor to do it at that price.

Colonel KENDALL—Before you go on I should like to know exactly what changes are made in the general disposition of the drainage?

Mr. AITKEN then explained the proposed outlet at the Prongs, produced a diagram showing the prevailing winds, and a section of all the main sewers to show the nature of the ground. He then went on to say :—If the outlet were carried further out to the end of the Prongs, or say one and a half miles from the present light-house, the estimate would be about nine or ten lakhs more. With regard to Captain Tulloch's remarks on my estimate, I wish to state that the main cost of any system of sewage is the brickwork, not the excavations, so that Captain Tulloch's remarks do not apply. I believe I have given very fair prices. Captain Tulloch thinks that I have not made a fair estimate, but I will take his price for excavation. He has a cutting; part of it 30 feet deep, the average depth of it being 23 feet, and yet it is only taken as 3 feet wide; it is 3,200 lineal feet long. Now, I never knew a cutting 3 feet wide and 30 feet deep, and at the bottom of that he is to have a four-feet sewer. His price is 40 rupees per brass, but mine is 20; my cutting will be all at least six feet wide, so practically the prices are the same. I think a great many of the present sewers can be utilized even for night-soil by a little humouring and repairs.

Colonel TREVOR—You mentioned just now that you had gone into the question of the utilization of sewage, and that it would not pay?

Mr. AITKEN—Yes, I am quite satisfied that it will not, if carried out as proposed by Captain Tulloch. In addition to other objections, I do not think there is sufficient land in the neighbourhood to utilize it. Here is a case. Twenty-eight years ago, when it was proposed to utilize it in London, they tried it at Fulham and elsewhere; and in 1848 it was proposed to utilize it, and also to work a water wheel for grinding corn.

Colonel TREVOR—What! with sewage?

Mr. AITKEN—Here is the report by Mr. Walker, Mr. Brunel, and Mr. Cubitt, all of them engineers of the greatest experience, and they ventured (as they all lived in Westminster) to express a hope that the experiment would not be made. I have made a fresh estimate of the scheme shown on the plan, and it comes to about 76 lakhs. If the outlet is made at the end of the Prongs, it will be 6 or 8 lakhs more. If the cutting to Worlee shown in the plan is made, that will be an addition to the estimate of the cost of the cut, there will be 2,31,000 brass of cutting. The excavations from this would be taken to raise the low lying ground near the Grant Road. The cutting would collect the rainfall, and as the tide went down, of course we should get a good fall. Of course the main question is between utilizing the sewage and throwing it into the sea. The outfall has been selected by a Commission appointed by the Government, and the Commission recommended that Government should pay for the outlet from the Oyster Rock to the Light-house outfall.

Mr. CRAWFORD—They (Government) simply stated that they would not receive the sewage nearer than the original point proposed—the Prong outfall. There was a resolution of the Government upon that point, and I have got it in black and white.

Colonel TREVOR—And nobody can wonder at their decision, considering that they have bought up all Colaba.

Mr. AITKEN—The Commission on the outfall question decided in favour of the light-house outfall and not the Prong outfall. The tube, if carried further down, will require several lakhs more; the question of the distance to which sewage should be taken along the Prongs is, however, subject for consideration; but surely a matter affecting the health of a town containing a million inhabitants must have some weight with Government notwithstanding their having purchased Colaba.

In the course of his evidence, Mr. Aitken handed in the following :—

1. Map (mounted) of the Island of Bombay, showing Mr. Aitken's drainage scheme, with tracing of the S. W. prongs showing outlet pipe and a diagram of the direction of the wind during a whole season—scale 600 feet to an inch.

2. Tracing longitudinal sections of sewers—scale horizontal 600 feet, and vertical 20 feet to an inch.

3. Tracing of longitudinal section of main sewer—scale 600 feet to an inch horizontal, and vertical 20 feet to an inch.

4. Tracing longitudinal section of new proposed cut across the Flats to carry off rain water—scale horizontal 600 feet to an inch, and vertical 20 feet to an inch.

One file Mr. Aitken's amended estimate, with sketches of the above works.

CAPTAIN TULLOCH.

The CHAIRMAN—I don't know, Captain Tulloch, if you are ready to give any evidence to-day. What the Commission is anxious to know is, whether there are any facts or arguments to be added to what you have already put in writing?

Captain TULLOCH—I would rather not give my evidence to-day. I should tell you that I arrived at my conclusions on the drainage of Bombay after much deliberation, and I adhere to everything in my report. Six months' consideration has only tended to confirm me in my views. I may say that I am almost certain that I can lay my main sewer three or four feet higher than I have it in my project; that is a very important point indeed. Beyond that, I have nothing at all to alter, and I am sure my project will now compare still more favourably with any other, because the pumping is reduced.

Colonel TREVOR—How will you be able to effect the alteration you speak of?

Captain TULLOCH—I think I have given too much slope to the last portion of the main drain; it need not have so great a fall. If you remember, Mr. Thwaites, when he explained the present system to you, showed that the sewer, where it at present terminates, was 20 feet wide and 10 feet high, with a slope of about one in 4,000, or practically level.

Mr. THWAITES—That is only for a short distance.

Captain TULLOCH—That was only for a short distance; now my sewer has a slope of three or four feet to the mile.

The CHAIRMAN—It seems that in some parts it is two and a half feet.

Captain TULLOCH—That is not the sewer, it is the one for sewage.

The CHAIRMAN—Oh, yes.

Captain TULLOCH—You will see that it is as I have said if you turn to the section of the main drain. I have given a slope of 4 feet per mile. It is evident from the plan itself that the black portion slopes much more rapidly than the other. And then I think I have provided for more rain than there really is. Mr. Sowerby draws attention to that, and I wish to explain that whenever I prepare a large project like this, I always make the facts as strong *against* myself as possible; I don't cut down anything to make it appear *favourable*, because afterwards when you come to work out the details you find you have not provided sufficiently for everything. Now, I believe, I have not nearly so much rain to dispose of as I have assumed in my report, and I have allowed nothing for evaporation and nothing for soakage, and have taken the whole area draining to Love Grove at more than it is; beyond that I have nothing to alter in the project; the estimate and everything remains precisely the same. I don't know whether you wish me to criticise anything Mr. Aitken has said, but it seems to me that he has not said anything new, or that can be borne out by facts.

The CHAIRMAN—We do not want to go into minute affairs, but into the main features of the scheme.

Colonel KENDALL—You still purpose to carry the Fort Drainage across the Esplanade to Love Grove?

Captain TULLOCH—I don't insist upon that at all. If the Government thought that the Fort was so small a place that the sewage might be discharged into the sea, I should not offer any objection. If this system were really found hereafter to be a nuisance, nothing could be easier than to rectify it, for all you would have to do would be to extend the main drain and pick up the Fort sewage. I have put the main sewer at a level to enable me to extend it so as to pick up the Fort sewage. This I have done in communication with Mr. Thwaites, who has given me the levels of the Fort sewers. I think you will see that at the outlet into the sea the level of the sill of the present Fort sewer is 53, and I can reach the Fort at a level of 53. If you really decide not to take the Fort sewage in, I shall lay my drains still higher, but I must tell you that my system of drainage is not designed in the ordinary way; if you only wanted the sewage to flow and nothing more, the sewers might be put considerably higher, but I think the slopes of all the drains, especially the subsidiary drains, should be such that no deposit should take place in them. I think there is only one subsidiary sewer of mine which has a slope of 1 in 400.

Dr. HUNTER—That is the minimum.

Captain TULLOCH—Yes. The average will be from one in 10 to one in 100 or 150, so that I do not anticipate any stoppage in the sewers at all. Now Mr. Aitken has said himself that in the Fort drain

the deposit—and I think this is a very important point—consists of only sand and grit, and no organic matter, and he maintains also that the night-soil is seen floating along the surface; if so, there will certainly be no deposit in my sewers, for no sand or grit can get in—nothing but waste water and night-soil. I think that is very fair testimony to the probable efficiency of such a system of drainage as I have proposed. There are one or two remarks I want to make on the general subject of drainage. It is a very large subject, and I did not come prepared with evidence to-day; but if you will let me, I will give it on another day.

The CHAIRMAN—Yes, I think so.

Colonel KENDALL—You must include in your remarks what changes or alterations you will make in the level of your main sewer.

Captain TULLOCH—I don't like to go into minute details till I have a great number of facts before me; by going too much into particulars at first a man is apt to make statements which he cannot afterwards establish, and so it is best in general to make an allowance on the right side. You see this project at its worst.

Colonel KENDALL—You must also give a few more explanatory remarks on your system of letting off the surface water and storm water. I did not quite understand the whole of what you said on that point, but I think the Chairman will be able to hear you on some other day.

The CHAIRMAN—Yes, I think so. I was going to ask you, Captain Tulloch, what quantity of land do you propose to take up for the utilization of sewage?

Captain TULLOCH—Between 400 and 500 acres. At present I should be very glad if the Commission would recommend that no land be taken, for I feel certain that if the pipe only is laid down the natives will take sewage themselves. You have only to prove to the natives that the water is useful for cultivation purposes and would be profitable, and I am certain they will take it.

Colonel TREVOR—Would you allow them to have the sewage water to do what they like with?

Captain TULLOCH—Yes, I would; natives are very alive to their own interests.

Colonel TREVOR—Do you mean without payment?

Captain TULLOCH—No.

Colonel TREVOR—I think you would want somebody to see that they did not waste it.

Captain TULLOCH—I don't think much waste would take place, but the state of the channels would have to be watched. In the case of sewage being wasted, you could punish them and not let them have the water. I don't think there would be any difficulty there.

Colonel TREVOR—I think there would be a good many practical difficulties.

Captain TULLOCH—There might be some at first, but I should think after a time all the difficulties would be got over.

The CHAIRMAN—Do you propose to give any evidence on the drainage schemes?

Captain TULLOCH—Yes.

The CHAIRMAN—You are not sufficiently prepared to do so to-day.

Captain TULLOCH—No; I would rather wait till another meeting.

MR. A. T. CRAWFORD, *Municipal Commissioner of Bombay, further Examined.*

The CHAIRMAN—Mr. Crawford, do you propose to give any evidence upon the drainage schemes?

Mr. CRAWFORD—Oh, yes; I shall be very happy to do so.

The CHAIRMAN—Are you prepared to do so now?

Mr. CRAWFORD—Well, I would rather not take the sewage utilization question to-day simply, but would deal with the financial part of the question.

The CHAIRMAN—Then perhaps it would suit you better to-day, if we ask you to state your opinion upon the financial part of the question. Have you any definite plan prepared? Supposing it will be necessary to raise seventy or eighty lakhs of rupees in order to carry out one or other of the schemes, how would you propose to raise it?

Mr. CRAWFORD—Simply by a drainage rate, as has been done in London and other places.

Colonel TREVOR—You would gradually supersede the halalcore cess?

Mr. CRAWFORD—Now you are going into another question altogether—whether night-soil is to go into the sewers or not?—that might, or might not, be done.

The CHAIRMAN—What rate do you propose to fix?

Mr. CRAWFORD—I cannot say.

The CHAIRMAN—Take the amount required at seventy or eighty lakhs?

Mr. CRAWFORD—I would spread the cost over a number of years, not less than half a century. Supposing the scheme to be a perfect one—sufficient for the future requirements of the town—I should provide for the extinction of the debt in a certain time. What rate would be required, would, of course, be a matter of calculation.

By Colonel KENDALL—What amount do you think it would be competent for the town to pay as a drainage rate?—A. Two lakhs and a half is the amount now set aside for drainage each year by direction of the Legislature, without the slightest reference to the cost of any particular system for the improvement of the town.

Colonel KENDALL—That is not devoted to drainage?

Mr. CRAWFORD—Yes, but it seems to have been set down in a hap-hazard way without the slightest consideration. Two and a half lakhs of rupees a year would give a sum equal to 2 per cent. on the house rate, and sufficient to pay the interest on 30 or 40 lakhs of rupees. A further rate of 2 per cent. would therefore pay for the drainage.

The CHAIRMAN—Two and a half lakhs would give the interest at five per cent. on fifty lakhs. But the two and a half lakhs are set apart out of the Municipal Fund, and are not the product of an additional rate?

Mr. CRAWFORD—No, not at all; it is deducted out of the proceeds of the Municipal Fund proper.

The CHAIRMAN—What drainage rate would these two and a half lakhs represent?

Mr. CRAWFORD—A rate of two per cent. And I think that two per cent. is a very large and fair contribution upon the part of the town, and that in a matter of this kind we should have, as we should expect, some assistance from Government, but whether we got it or not—with the town increasing at the present rate—with a 2 per cent. rate, yielding two and a half lakhs, the cost of the drainage would be paid in the course of fifty or sixty years.

Colonel KENDALL—We are to look to the realization of the present.

Mr. CRAWFORD—Then the alternative is to extend the term of payment over three-quarters of a century.

The CHAIRMAN—Do you expect any further assistance from Government than a guarantee from Government for any loan that may be necessary?

Mr. CRAWFORD—I cannot say that I do expect more than that Government will lend the money at 5 per cent.

The CHAIRMAN—Is the sum of two and a half lakhs applied every year, now appropriated to drainage works?

Mr. CRAWFORD—Yes.

Colonel KENDALL—Has any fund accrued from this, and is it kept as a separate account?

Mr. CRAWFORD—There should have been seventeen lakhs upon the 1st July 1865; but the former Corporation either did not pay the amount, or, having paid it, appropriated it for other purposes.

Colonel KENDALL—Is there anything now on that fund?

Mr. CRAWFORD—Nothing whatever. The Justices, at their first meeting after the 1st July 1865, when I brought the financial condition of the Municipality before their notice, with the intention of getting the income of the Municipality brought up to a point sufficient to pay the expenditure, requested me to borrow from the Drainage Fund, the result of which was that until the deficit was wiped off, the whole of the Drainage Fund was drawn upon until it was extinguished.

Colonel KENDALL—Was that with the sanction of Government?

Mr. CRAWFORD—Not at first—the sanction of Government was recently obtained.

Colonel TREVOR—There is nothing standing to that account now?

Mr. CRAWFORD—No; there is a loan account. I should wish to ask Mr. Aitken a question with reference to what he said he inferred as to the reason why the drains were not being proceeded with. He said he could only guess. What did he mean by that?

Mr. AITKEN—No, I did not say so; I said I could only guess.

Mr. CRAWFORD—Well, I should wish to know what you meant by saying you could only guess. Statements of that kind are injurious. I should like you to state what you mean as to guessing what my reason was?

The CHAIRMAN—Will you be good enough to give us your reasons, Mr. Crawford?

Mr. CRAWFORD—I should wish Mr. Aitken to answer me first.

The CHAIRMAN—Well, I do not know that it is necessary.

Mr. CRAWFORD—The real reason was this. The Justices only sanctioned the completion of certain lengths of the Fort system of drainage when the estimates were brought up in detail. On that occasion, General Tremenheere—on very good grounds, I think—proposed that the Fort sewage should not be prosecuted until the general question of passing night-soil into the sewers had been decided one way or another. I thereupon stated to the Bench that I would not proceed further than the completion of that portion in Elphinstone Circle, Hornby Row, and the eastern boulevard, unless with the further sanction of the Bench. That was how the matter stood at present. The question which General Tremenheere raised was at present unsettled, but the money was available at any moment.

Colonel KENDALL—How much ?

Mr. CRAWFORD—Well, deducting the cost for the Camateepoora sewage, there are about 4½ lakhs.

Colonel TREVOR—Then you have enough to finish the Fort drains.

The CHAIRMAN—What money have you raised for drainage purposes ?

Mr. CRAWFORD—About seven lakhs.

The CHAIRMAN—That is only a loan of the Municipality for drainage purposes ?

Mr. CRAWFORD—Yes.

The CHAIRMAN—Is it the six per cent. loan ?

Mr. CRAWFORD—Yes.

The CHAIRMAN—Payable in how many years ?

Mr. CRAWFORD—In 20 years ; the sinking fund is one-twentieth in each year.

Colonel TREVOR—Is there a drainage loan then ?

Mr. CRAWFORD—Yes, secured upon the house rate.

The CHAIRMAN—Is the whole amount of that loan taken up ?

Mr. CRAWFORD—Yes.

The CHAIRMAN—What was the whole amount sanctioned ?

Mr. CRAWFORD—Deducting the cost of those drains which have already been made, the whole amount of the estimates for the works proposed was Rs. 7,20,000, out of which I obtained sanction from the Bench for about Rs. 80,000, and Rs. 2,40,000 for the Camateepoora drainage. The amount of the loan raised was about Rs. 7,00,000. With regard to the financial part of the question, I only wish to state that this two and a half lakhs per year, which I think represents two and a half per cent on the house rate, would amply pay for a system like that of Captain Tulloch's, which purposes to deal with the present system and provides for the surface drainage and storn waters.

Colonel TREVOR—Do you think it expedient going on borrowing so much money as is required for the extension of the drainage and the water supply at the same time ?

Mr. CRAWFORD—I do not think the question of expediency arises at all here, because in the recent determination of the Government of India to lend to the Bombay Municipality the sum the Municipality now require, in its recent loan to the Calcutta Municipality of 52 lakhs for water works, and in its recent loan to the Kurrachee Municipality, I see evidence of the intention of the Government of India, that Municipalities shall not have to go into the market, but that the money they require shall be advanced by the State upon certain conditions. The question of the expediency of going into the market for a loan will never arise. It will become a State question, and every loan we shall raise hereafter will be with a State guarantee. The question of expediency, therefore, will never, as I before said, arise. For, of course, the State will see that due provision for payment is made.

Colonel KENDALL—But you will only get the money when there is a certainty of the Government being repaid ?

Mr. CRAWFORD—Obviously.

Colonel TREVOR—Not with a seventy years' loan. You won't get a loan on those terms.

Mr. CRAWFORD—Then with one for fifty years. This is for Government consideration.

Colonel TREVOR—That is a very long time for the Government to lend money.

Mr. CRAWFORD—They have lent it for a much longer period for the Vehar Water Works. I am hopeful Government will not take this narrow and contracted view of the matter, but will regard it liberally ; and I am of opinion that Government is bound to supply us with the money we want for such a purpose.

Colonel TREVOR—It is a large question if every place is to draw upon the Government treasury.

Mr. CRAWFORD—This is an imperial as well as a local question. That is what I have advocated for years.

The CHAIRMAN—Have you given your attention, Mr. Crawford, to the question of deodorising the sewage with dry earth?

Mr. CRAWFORD—I have given considerable attention to it.

The CHAIRMAN—Do you think that scheme would be practicable in Bombay?

Mr. CRAWFORD—Most decidedly not. I only speak upon the evidence of those who have worked out the details, but I think with regard to it that it would be impossible to work it; and that for sanitary reasons it would be objectionable in the highest degree. It may be all very possible to work it in hospitals which are under strict discipline, and in establishments like Watson's and so forth; and it might be proper that they should use the system of deodorisation, but for the same reason that I objected to the connections of the water pipes into the poorer classes of houses should I object to the introduction of the dry earth system. The people would not use it.

The CHAIRMAN—Then I suppose you would also object to any system of water closets in Bombay?

Mr. CRAWFORD—Well, that is a question which I hope will be worked out next year. I may state that in consequence of General Tremenheere's remarks on the subject, I, as president of the Bombay Mechanics' Institute, offered a premium for a design for the best system of water closets for natives. Two of the designs sent in were selected, and sent home to England for an estimate as to the cost of manufacture. By the last mail from England I received the estimates, and also some remarks by an engineer of some reputation at home, and I hope that this year the Mechanics' Institute—which I may observe is a very suitable body for such enquiry—will be able to work out the question satisfactorily. For myself, I am inclined to think that water closets cannot be used in Bombay, or in any Indian city.

The CHAIRMAN—Do you know how the experiment of introducing water closets in the houses in Elphinstone Circle has turned out?

Mr. CRAWFORD—I have only the evidence which Mr. Aitken presented last year in his annual report. The ventilation is very bad, and their introduction there has not been a very great success.

The CHAIRMAN—Do you know if the native clerks are allowed to use the closets in Elphinstone Circle?

Mr. CRAWFORD—I believe not. I think the seats have been screwed down in their privies.

The CHAIRMAN—That would be a very good test of the practicability of water closets then?

Mr. CRAWFORD—No, I think not. The closets there are only adapted for Europeans. There is no attempt to adapt them to the habits and customs of the native community. The thing to show is, that even when so adapted they will not suit. My own view of the general question of passing the night-soil into the drains is, that at present we do not know enough about it to enable us to decide, and that until we do know by means of a system of experiments whether night-soil can, or cannot be, safely introduced into the sewers, that night-soil should not be introduced into them.

The CHAIRMAN—Would you continue, then, the present system of removal by hand?

Mr. CRAWFORD—For the present certainly, continuing at the same time experiments in every way. As President of the Mechanics' Institute, I may state that I am now upon the point of offering prizes for any system of utilizing or getting rid of the night-soil of the town in any way less offensive than at present. It is an exceedingly difficult problem which will take some years to work out, but I do not see why it should interfere with the completion of a proper system of sewage.

The CHAIRMAN—With regard to the present system of discharging night-soil into the harbour at Carnac Bunder, have complaints been made about it?

Mr. CRAWFORD—No, except from the Custom House, which is situated a few yards off the discharge pipe, I cannot say that there have been any complaints.

The CHAIRMAN—Not from people on board the shipping? Do they complain of its being a nuisance?

Mr. CRAWFORD—No, there have been no complaints whatever from that quarter. There are one or two local steamers which rather seem to like it—(laughter)—for they anchor just over the mouth of the sewer.

The CHAIRMAN—Have you made any experiments as to the distance at which the soil is carried down the harbour?

Mr. CRAWFORD—There have been some with floats. But I do not think the experiments were satisfactory or conclusive. The most notable was the one made by Mr. Forjett, but I don't think the experiment was satisfactory because the float was acted upon by the wind, whereas night-soil discharged in the ordinary way, gradually sinks into the sea and becomes diffused.

The CHAIRMAN—A large quantity is taken up by marine birds?

Mr. CRAWFORD—I do not think that they can get down to the depth at which it is. The soil is now discharged from a pipe with a lip which directs the soil downwards, and to the level of the bottom of the sea, so that when it falls out of the pipe, there may be a depth of fifteen feet of water over it. Looking at the existing condition of the town, I think that the present system of disposing of the night-soil is as inoffensive as can be devised. I do not mean to say it is perfect; very far from it. I would add that I much hope something may be done which will enable us to utilize this enormous mass of very useful material. But it must be borne in mind that we have everything against us. It is the distance and cost of carriage which is death to us in everything of the kind. If any feasible plan could be hit upon, it would be a very great boon to the town, because there is no reason why the market gardeners should not contract—as is the case at Surat—for the whole of the night-soil.

The CHAIRMAN—Is that the case at Surat?

Mr. CRAWFORD—Oh, yes.

The CHAIRMAN—Do you know what the cost is?

Mr. CRAWFORD—I can give you the results another day. It is the same with the sewage of Poona.

Dr. HUNTER—How far from the town are these market gardens at Surat?

Mr. CRAWFORD—Quite close. The greater number of the cabbages from Surat which you see about are grown in these gardens. Until recently the people at Surat used to send their own carts for the night-soil.

Dr. HUNTER—Was not cholera prevalent in Surat last year?

Mr. CRAWFORD—You can find cholera there at any time. This manure is called *Sona Khat*, or "the golden manure."

The CHAIRMAN—How is the sewage removed there. In open carts?

Mr. CRAWFORD—They have cesspools from which the soil is removed in carts. The carts then take the soil to the market gardens where there are holes. The soil is tipped into the holes, and a little earth is thrown over the top. Very much the same system is followed in large gaols—one or two of which I have had charge of myself. In the morning, Chinamen remove the night-soil, and deposit it in a trench, which is then filled and covered in, and then another is opened and filled in the same way. After about six months, the trenches are opened and the soil is sold to the native cultivators, at a considerable profit. Very much the same system is followed in the North-Western Provinces.

Dr. HUNTER—I think there was cholera at Poona last year?

Mr. CRAWFORD—Yes; and at Ahmednuggur (?) and other places. It must be understood that I would never advocate the utilization of sewage in the immediate neighbourhood of Bombay. As to the value of manure, I may add that sheep's dung in large quantities has been taken from the slaughter houses at Bandora, to Mehmoodabad, a place nearly 300 miles from Bombay.

The CHAIRMAN—Mehmoodabad is in the Kaira Zillah, and near Ahmedabad.

Mr. CRAWFORD—Yes; in the same way it may pay to carry away night-soil.

The Commission then adjourned.

NINTH DAY. TUESDAY. APRIL 27.

The following Commissioners were present:—

ANDREW R. SCOBLE, Esquire, *Chairman.*
Colonel KENDALL, R.E. | Lieut.-Col. TREVOR, R.E. | Dr. HUNTER.
Dr. LYON, *Secretary.*

The Commission resumed at 2 o'clock on Tuesday, in the Durbar Room, Town Hall.

DR. LUMSDAINE:—

By the CHAIRMAN—I believe the task of cleaning the drains is under the Health Department?—A. It is.

Q. Will you describe the system that is in force at present?—A. There is an establishment for drain cleaning, and it is chargeable to the Health Department. The inspectors who attend to scavengering also attend to the drain cleaning. The working gangs work under their directions.

Q. How often are the drains cleaned?—A. The cleaning is continuous all over the town.

By Colonel KENDALL—Do you clean drains before they are reported as stopped up?—A. No; but the necessity for cleaning them is constant.

Q. But is the necessity seen from their being stopped up?—A. Yes; it shows at some one point or other.

Q. Is there any record as to how frequently these drains get stopped up?—A. I have returns, but they are not here. We send intimation to the Executive Engineer.

Q. Do you find some drains more frequently stopped than others?—A. Yes; those in the more crowded localities.

Q. Are they all of the same section?—A. I think not.

Q. You never made enquiries as to whether it was at all due to the construction of the drain?—A. If we were to make enquiries we should not get satisfactory answers, because we don't send skilled labourers to the cleaning, but merely our ordinary coolies.

Q. Have you ever suggested any report from the Executive Engineer as to the cause of the drains being stopped up?—A. No; it is apparent, and is owing to the washings from streets and gullies running into them. They get constantly choked with road refuse and washings.

Q. Not with night-soil?—A. Well, there is night-soil, but not sufficient to cause any stoppage. I think we remove the greater part of it.

Q. And then how are these drains cleaned?—A. The surface of the road is broken up, and the drains are then laid open. The material is put into carts and carted away. The men could go into the larger drains, but I rather discourage that, as I am not sure about the ventilation.

By the CHAIRMAN—How are the open gutters by the road side cleaned?—A. They are just swept, and every time they are swept they get perhaps worse than before.

Q. Are the contents removed in carts?—A. Yes.

Q. Is that done daily?—A. Yes.

Q. And what becomes of the sweepings?—A. They are sent to Coorla.

By Colonel KENDALL—From what, in your opinion, does the stoppage of the drains arise?—A. I fancy from their faulty construction—I don't mean of the principal drains, but of the subsidiary ones. They are very shallow and generally square; they are either unpaved or badly paved.

Q. Does much get into the drains besides the ordinary night-soil and waste water and street sweepings ?—A. There is little else that could get in.

Q. But no large hard substances ?—A. No; but a great deal of silt does. Most of the obstructions are from silt washed in by profuse watering, &c.

Q. How are these drains ventilated ?—A. There are perforated stones at intervals.

Q. Communicating with the drain of the street ?—A. Yes; along the centre line.

Q. Are these offensive at times ?—A. Exceedingly so—especially in the early mornings in the ill-ventilated native town.

Q. Were you here last monsoon ?—A. Yes; I had just taken charge at the end of July.

Q. How did the drains act then with the storm water ? I suppose they took off most of it ? Did that flush them well or in any case break them up ?—A. I don't think there was any case in which they were broken up. I fancy the monsoon is our best time. The drains are necessarily cleaner as they are so well washed out.

By the CHAIRMAN—Have you ever heard of a stoppage in the Carnac Bunder pipe ?—A. There was one soon after I took charge. It was owing to some fault in a joint.

Mr. AITKEN—That was a burst, not a stoppage.

Dr. LUMSDAINE—I don't know what it was, but it stopped the exit from the tanks. That is what I mean by a stoppage. It interfered with our work. It was right across the railway, but it was soon repaired, and only deprived us of our depot for one night. We had not another stoppage till Saturday last, from which time until now (Tuesday) the pipe has been completely plugged. The tanks are now full of the night-soil that was put into them *seven* days ago, and there are no possible means of getting rid of it.

Q. Do you find a difficulty then in ascertaining the point at which a stoppage occurs ?—A. There was the greatest difficulty. It was handed over to Mr. Pyne, the Superintendent of Water Works. He did not know whether it might be under the railway or under the bridge, but he exposed the pipes at certain points and drilled holes in them. He commenced down by the eastern end of the over-bridge, but it was clear to that point there was no escape, showing that the stoppage was above. Then he went up further and drilled another hole, and that too was clear. Then he went up immediately above the railway, exposed the pipe there and drilled into it, and the sewage escaped; so the stoppage was between the last two mentioned points, and fortunately for us it was not under the railway nor the bridge.

Q. And you have not been able to clear the stoppage ?—A. Not yet. Mr. Pyne only came down on it this morning at about 7 o'clock, and he now knows that it is within two points 25 feet apart.

Q. The stoppage of that pipe practically suspends the whole halalcore service of the town ?—A. We have to devise a make-shift, which is not desirable. When it occurred there was a great deal of night-soil on the depot pavement, and we had no means of getting rid of it. Fortunately that night the level in the tanks sank some two feet, and that enabled us to get rid of it off the pavement.

Q. I suppose you can shut off the tanks from the pipe ?—A. Yes; there are valves.

Q. In the meantime, till the pipe is clear, there is no possible means of emptying the tanks ?—A. No.

By Colonel TREVOR—What is the size of this pipe ?—A. Fifteen inches.

By Colonel KENDALL—Do you know when it was laid down ?—A. No; I don't know. Mr. Aitken will be able to tell you.

Mr. AITKEN—It was laid 15 months ago. The old Chinch Bunder pipe used to get stopped up, and this was made as a substitute.

Dr. LUMSDAINE—The stoppage is at a point between the steps of the Carnac overbridge, and where the pathway leading over the bridge is turned on to the reclaimed ground. It is not in a bend; it is between these points.

Mr. AITKEN—They have been making a drain, and there may have been some settlement of the pipe.

Colonel KENDALL—Was the pipe laid on made ground ?

Mr. AITKEN—Yes; and they have been making a drain, and the tide may have made a hole and caused the pipe to settle down. The previous case was not an obstruction of the pipe; it was owing to a bad joint that began the leak. The railway people had laid the line and brought down the sleepers to within two feet of the pipe. That shook the pipe, and the consequence was, that the lead in the joints was loosened, but there was no absolute stoppage, though they could not allow the night-soil to go out of the depot on account of the boiling up at this place.

Dr. LUMSDAINE—Considering that the tanks could not be emptied, I should say there was *absolute* stoppage. Mr. Pyne has put on the pressure of the Vehar Water and done everything possible, but the stoppage is so hard that he cannot run a rod into it. It is of clay and sand.

Colonel TREVOR—How could that have got in?

Mr. AITKEN—There may have been a nucleus deposited.

Colonel TREVOR—If there are to be obstructions of this kind, would not that be an objection to your scheme, Captain Tulloch?

Captain TULLOCH—Oh, no; the new scheme of drainage is so arranged that every part is under control. Wherever there is a bend there is a man-hole, so that when a stoppage takes place you open one man-hole, and can clear out the drain by putting in a chain and plying it along to the next man-hole some 150 feet further on. Thus the stoppage is cleared, and that is the secret of proper drainage. But I presume this pipe has a bend, and you can't see where the stoppage is.

Mr. AITKEN—It is below the bend.

Captain TULLOCH—Can you see practically where the stoppage is?

Mr. AITKEN—Dr. Lumsdaine has told us it is below the bend.

Captain TULLOCH—Yes. But can you tell within 10 feet?

Mr. AITKEN—Within 100 feet.

Captain TULLOCH—A *hundred* feet!

Dr. LUMSDAINE—They can tell now; but when they commenced they could not tell where it was.

Captain TULLOCH—That is the whole secret of the new system at home. In fact, it is the duty of the establishment to see that the drains are kept clean, and then they should go along all the streets and enter the man-holes and look down to see that the drain is clear along to the next man-hole. They can do so by by putting a light at the other end, and if that is seen, then the pipe is clear; whereas if there is a deposit they can't see the light, and ought to bring a brush and clear out the drain. But if you allow the deposit to accumulate till it becomes 20 or 30 feet in length, a tremendous pressure is required to clear it away, and that is the reason why in my project I have allowed for a man-hole at every 200 feet.

Colonel TREVOR—That is close enough.

Captain TULLOCH—Yes; that ought to be sufficient for every purpose.

Mr. AITKEN—I may say that the old Chinch Bunder pipe, which had 15 feet of water, used to get stopped up, and it was the same size as this one.

The CHAIRMAN—You have not given us any evidence yet as to your opinion regarding sewage utilization?

Dr. LUMSDAINE—I am in favour of it; of course, it all depends on the way in which it is conducted. Supposing it is conducted properly, I am in favour of it.

Q. Under what conditions would you place it in order to be sure of its being properly conducted?—A. I think in every tropical country the conditions are peculiarly favourable.

By Colonel KENDALL—Were any parts of the town flooded during last monsoon?—A. A very great portion of it was.

Q. That was during an exceptionally heavy fall of rain?—A. A very heavy fall—on the 12th August.

Q. What parts of the town were flooded?—A. The Camateepoora district, the Flats district, Khetwady, Girgaum back road, and the districts in that direction generally—from Camateepoora by the Club, Race Course, the Flats, and Khetwady.

Q. How deep was the water in those parts?—A. The water washed into the windows of a brougham.

Q. Then where did it drain from, or what was the cause of that? Did it drain down from Malabar Hill and the higher grounds?—A. I fancy it was almost due to the immense rain-fall—over 14 inches fell in 24 hours.

Q. And did it subside of itself and run off?—A. Yes; there was no artificial means of getting rid of it.

Q. How many days did it lie?—A. Several days.

Q. Did you notice the channels drained into?—A. It drained northward. From these districts it would run northwards.

Q. But did the surface drains of all the streets all drain towards the lower part of the Flats?—A. From that part of the town I think they all tend to the existing main drain.

Q. And that is the only mode of escape the water has—through the Love Grove sluices, I suppose?—A. That is all.

Q. Were the Flats covered with water up to the sluices?—A. Yes; the whole way.

Mr. AITKEN—The main drain was running full bore up to the key of the arch.

By the CHAIRMAN—As to sewage irrigation, Dr. Lumsdaine, at what distance from the thickly-inhabited parts of the island of Bombay do you think sewage irrigation ought to be conducted?—A. Well, I would say as far off as you can keep it—certainly not within a mile of the town.

Q. I suppose you would rather have it out of the island altogether?—A. Yes; but I think there is a great deal of waste land which would be improved by it.

Q. What is your opinion as to the proper proportion per acre in which sewage ought to be applied to the land, having regard to climatic and other influences?—A. I think I might almost say an unlimited supply in this country. In England thirty thousand tons distributed over 300 acres is equal to an inch of moisture; more could of course be used here.

Q. Then you do not think there would be any sanitary difficulty from the distribution of sewage in Bombay over a smaller area comparatively than that hitherto tried in England?—A. None whatever. It would be applied in such a state of dilution.

Q. Have you tested the condition of the sewage at the time of its discharge?—A. Dr. Lyon has very kindly analysed it as it is discharged where the new closed drain commences. There is another sample now under analysis from the pumping station at Love Grove, which will give us the condition of the sewage in the main drain; and there is a third sample under analysis of the Fort sewage, where the two sewers unite and form one at the outlet into the harbour.

Q. Do you think that there would be any dissemination of the cholera principle by sewage irrigation?—A. No; I do not. The sewage would arrive in such a state of dilution, and would be at such a distance from the town, that you might safely put it on the land. I think the Sanitary Conference gave 136 feet as the distance at which the germ is supposed to be noxious, and here you would have it from 2 to 6 miles away.

Q. Have you read the abstract of the proceedings of the Sanitary Conference?—A. I have.

Q. You remember at page 33, it is stated "that in an epidemic of cholera the earth itself of the place where the disease prevails has a great share in its development by the emanations that escape from it. Thus a porous soil, easily permeable to water and air, and charged with excrementitious matter (consequently an alluvial soil, a marshy soil), impregnated with choleraic dejections, becomes at first a receptacle, then, according to circumstances, a source more or less active, from which the principle of the disease issues." Do you not think that sewage irrigation, in a place like Bombay, where it would necessarily contain a greater or less quantity of the cholera principle, would be likely to prove injurious to health?—A. I don't think that extract applies to sewage irrigation. The soil alluded to as easily permeable to water and air, and charged with excrementitious matter impregnated with choleraic dejections, is that ground in towns covered with privies and cesspools, where there is no drainage, and where day by day the foul soakage increases until it may be said there is fecal saturation. This is a condition of danger; but with sewage irrigation it would be very different. There would be drainage; and the sewage, immensely diluted, would spread over a large area; it would be far too diluted to form the paste that Dr. Hunter spoke of as likely to be blown about by the prevailing winds, and would be rapidly absorbed—it would be consumed by the vegetation it produced.

Q. Are there any other points on which you wish to give your opinion as to drainage—any suggestions you wish to give as to improvement of the present system?—A. It is hardly within my province to give an opinion on that. I can see that improvement is much needed, but it is for engineers to say how it could most effectively be carried out. I may take this opportunity of explaining that I spoke in favour of the present halalcore service being continued. I did so because as yet, I have not heard of any tested method by which you can get rid of the gases that would be engendered if the night-soil were passed into the drains. Until this problem be solved, we had better keep to our old system—disgusting and rude though it be. If there is to be water carriage there must then be water closets, and it will take some time I think to adapt the native houses for these. Admit that they would use them, and there is still the difficulty about repairing them—they would also require a continuous water service—and, no matter how much the payment was in arrears, you could never cut off the supply.

By Dr. HUNTER—I understand that you have said, Dr. Lumsdaine, that you consider the spreading of the sewage over the land would not be injurious to the health of the inhabitants?—A. Yes;

provided the sewage is disposed of at a sufficient distance from the town, and not directly to windward.

Q. What distance would you make it?—A. Well, I would rather not have it placed on the island at all.

Dr. HUNTER—If that is your opinion, I need not proceed further with the examination. Are you acquainted with the dry-earth system?—A. Yes.

Q. Are you aware that Dr. Mouatt, who was strongly in favour of the system, now seems to have some doubts as to its efficiency? He says, when the admixture with earth is carelessly performed, or when the earth used contains a large amount of moisture, the fermentation of excrementitious matter will take place, and disease will be the certain and sure result. Dr. De Renzi states that in the Punjab gaols the fact remains that, in spite of the most thorough deodorization of excreta, the contagiousness of gaol fever continues unchanged. Liebig and Pettenkofer are opposed to the system on scientific grounds.—A. But I do not propose to utilise the sewage by the dry earth system. I think you could utilise the sewage in the island without danger to the health of the inhabitants.

Q. By the same plan which is employed at Croydon?—A. Yes; but we have a very different climate here.

Q. Then I understand that what you advocate, Dr. Lumsdaine, is that the sewage should be taken away a certain distance from the island of Bombay, and then utilised for agricultural purposes?—A. Yes.

Q. What amount of solid matter do you suppose that this town sewage contains?—A. About two or three pounds to the ton; that is the proportion in the London sewage.

Q. Do you think it would be higher here, or nearly the same?—A. Nearly the same.

Q. In what direction is there any locality that would be available for utilization of the sewage?—A. To the northward of the island.

Q. How far off?—A. From two to six miles.

Q. Is that an inhabited or uninhabited district?—A. Strictly speaking, there is no part of Bombay uninhabited, but there are districts very sparsely peopled, and it is here I would have sewage irrigation.

Q. Do you consider that the throwing of this wet sewage upon the surface soil would have no ill effects on the inhabitants in the neighbourhood?—A. None whatever.

Q. Can you give us the result of any experience you have had?—A. I have had no experience on the point.

Q. Upon what scientific ground do you base your opinion?—A. I think it would be very little more than irrigation with simple water, and that is not a source of danger.

Q. The sewage which has been analysed, and to which you have referred, was taken from the main drain, was it not?—A. Yes.

Q. Is there no smell in it?—A. Yes; when you first go to it.

Q. What is that smell from?—A. From organic matter.

Q. Organic matter in a state of decomposition?—A. Yes.

Q. And do you consider that organic matter in a state of decomposition would not be detrimental to health?—A. Not necessarily so; it entirely depends upon *how* you use it.

Q. How would you avoid bad smells from it?—A. The earth would deodorise it; but I would not bring it into the close vicinity of the town, or to windward of the town.

Q. Having got rid of the ill effects of the smell that might be caused, do you still think there would not be bad results to health?—A. None whatever.

Dr. HUNTER—I understand you to say that organic matter, even when rapidly decomposing, is not unhealthy?

Dr. LUMSDAINE—No; I do not say that. I do not mean to imply that.

Q. Well, I understood you to say so. I asked you what the smell was from, and you said it was from decaying organic matter.—A. True; but it is to be spread over a large area, as a mere film, and will at once be deodorised.

Dr. HUNTER—The analysis of the sewage water shows it to be highly charged with sewage. The water taken from the drain is found to contain nearly three pounds per ton of solid matter, partly suspended and partly dissolved. And this sewage you propose to throw on the ground, because you say you think it would have no ill effects upon the health of the people.—A. I don't think it would, for deodorization and absorption would be too rapid.

Dr. HUNTER—I am sorry to say I don't agree with you.

Dr. LUMSDAINE—I do not propose to bring the sewage to windward of the native town.

Dr. HUNTER—But wherever it is, there must be people to superintend its application?

Dr. LUMSDAINE—Yes. In the old days there were the night-men at home, and I do not know that they suffered from their occupation.

Colonel TREVOR—Have you seen this chart of Mr. Russel Aitken, showing the directions from which the winds blow in Bombay? (Chart produced.)

The chart was inspected by Dr. Lumsdaine, who produced another chart, projected from the readings of the self-registering anemometer for 1868.

CAPTAIN TULLOCH, *further Examined.*

The CHAIRMAN—Captain Tulloch, you have some more evidence to give before the Commission?

Captain TULLOCH—I do not know whether you wish to put any questions to me with reference to my project? Colonel Kendall was questioning me at a previous meeting on certain points, and, if he wishes, I shall be very glad to answer his enquiries instead of going into my project fully.

Colonel KENDALL—I do not know whether you have any remarks to make generally upon your scheme, or whether we are to consider what we have before us as your complete project?

Captain TULLOCH—This report is a description of my project, which will work out in detail much better than it may even appear in the report.

Colonel KENDALL—We can only judge of what we read; but we shall be glad to have your account of the project, as I said the other day.

Captain TULLOCH—If I can put my main drain a few feet higher, it will make a very material difference throughout the project. Now, for instance, if you should determine not to take in the sewage of the Fort into the main sewer, I could probably begin the main sewer from near the market at a higher level. If you observe, this sewer is extended in order that it may take up this Fort sewage (referring to plan). But if you determine to discharge the sewage of the Fort into the harbour, there would be no reason why the sewer near the markets should be at so low a level.

Colonel KENDALL—That I quite understand; but what I should like to know about the sewer is whether it can be made more direct and without having so many bends in it?

Captain TULLOCH—It looks very bad upon the plan; but in reality the curve is ample. The rule with regard to sewage curves is that no curve shall be less than eleven times the diameter of the sewer.

Colonel KENDALL—Yes; but the fewer curves you have the better.

Captain TULLOCH—Undoubtedly; but if you will look to this plan (plan produced), you will see why I have followed the course marked out. The question you asked me was with reference to the line I have adopted. Mr. Sowerby, who has written on the subject, from not knowing Bombay has made some most ridiculous mistakes. He thinks, for instance, that my sewer is on the wrong side of the town, and says it will be better to carry it along the other side. Now, before I proposed this route, the first thing I did was to draw out my line without any regard to the existing system of drains, and the result was that, without knowing it, I laid my main sewer right along the exact line of the present main drain. On completing my plan, I went to Mr. Thwaites, the engineer in charge of the Drainage Works, and said—"Here is the best line for the main sewer; is there any objection with regard to the present works?" He said, "Why, you have taken the exact line of the present main drain." I replied, "In that case I must alter the line," because there would be no room in the street to build another sewer by the side of the present main drain. Accordingly I did alter it, and worked on both sides of the main drain, putting the sewer first on one side and then on the other, and getting out the slopes of some hundreds of the pipes in order to ascertain what was the greatest and what the smallest slope I should have to deal with, and to find out the general working of the system. If, as Mr. Sowerby suggests, you put the main sewer on the north of the present main drain, you will get very bad slopes; but in laying the pipes to the south of the present main drain I secure the best slopes. (Witness here produced a plan of the drain.)

Colonel KENDALL—I am not talking about these slopes; I am only asking you your reasons for the sewers not being straighter.

Captain TULLOCH—Well, if you look to the map, you will see that *there are no other streets which are in a more direct line.* If you decide to take the sewer along the line of the present main drain, this is the first street (pointing to plan) along which it will pass to the south. It goes as straight to the drain as you could get it to do. In fact, the sewer is as direct as it can be.

Colonel KENDALL—That was my reason for asking the question. I wanted to know what your reason was for taking the line you have. Your present main sewer crosses the existing main drain.

Captain TULLOCH—Yes; once.

Colonel KENDALL—I see in your supplementary report some remarks of yours on this mode of carrying one sewer under another?

Captain TULLOCH—Yes. At Hamburgh the sewage is carried right under the canal, which I think is 150 feet wide at that spot. Everything you put in at one side of the pipe under the canal comes out at the other side.

Colonel KENDALL—Have you seen that yourself?

Captain TULLOCH—I have. I have been into the sewer there.

Colonel KENDALL—What is the slope? What is the difference in the level?

Captain TULLOCH—Something very slight; they cannot afford much slope, for Hamburgh is very flat.

Colonel KENDALL—Did you take any exact data of the precise difference in the level?

Captain TULLOCH—No; I did not.

Colonel KENDALL—What would it be here? What do you allow in your scheme?

Captain TULLOCH—A couple of inches would be ample.

Colonel KENDALL—You think so?

Captain TULLOCH—Yes; ample. Everything we put in the syphon sewer must come out at the other end.

Colonel KENDALL—But we are talking of sewage, not water.

Captain TULLOCH—Well, the sewage will make no difference. Anything heavy will pass out, just as in a water closet.

Colonel KENDALL—Would you have any difficulty in passing the sewage under the existing main drain?

Captain TULLOCH—Not the least.

Colonel TREVOR—Do you not think these syphons would be traps for collecting silt and gravel?

Captain TULLOCH—No; you do not find silt collecting in syphon traps. What enters at one end must go out at the other. And if you have a man-hole at the point where the sewer crosses the drain, a deposit could be removed by manual labour without difficulty.

Colonel TREVOR—It requires a good deal of thought to understand that.

Colonel KENDALL—And a good deal of faith too.

Captain TULLOCH—You have only got to try the experiment in your own railway yard in Bombay, and you would be convinced.

Colonel TREVOR—That water will pass through I have not the least doubt.

Captain TULLOCH—But put in sand or other heavy substances, and you will find they will all come out at the other side too.

Colonel TREVOR—That does not accord with our experience on roads in India. We have a good number of these syphon pipes used for carrying water over from one side of the railway to the other, and they invariably get plugged up.

Captain TULLOCH—I do not know how they are laid down; everything would depend on that.

Colonel TREVOR—There is a syphon with a six-inch pipe. These drains are not well managed.

Captain TULLOCH—I have not heard of a syphon trap becoming blocked up. It is generally the pipes that are stopped. As a rule, the syphons act very well.

Colonel KENDALL—At page 32 of your report I see you arrange that the storm water should be allowed to run along the sides of the roads till it finds an underground drain into which it will pass, and it will then flow on till it enters the present main drain, where it can be pumped into the sea, or run through the sluices. The storm water goes out at a level of 37·5, or 8 feet below low water, so how could any storm water brought down through this drain escape through the sluices into the sea? It must all be pumped up.

Captain TULLOCH—In the case of a storm, of course the water would all be pumped up into the sea.

Colonel KENDALL—One is rather misled by your report.

Captain TULLOCH—The pumps can beat the main drain when it is discharging nearly full.

Colonel KENDALL—But then the question is, that by this remark you would lead us to suppose that a portion of the storm water escapes through the sluices, whereas nothing can escape through the sluices, but all must be pumped.

Captain TULLOCH—No water from the town would escape through the sluices. This was never intended. The discharge from the main sewer would be continuous, because the engines would be pumping it dry, and so long as the engines were doing so at one end, the water must flow in at the other.

Colonel KENDALL—I am not talking of the necessity of pumping. I am only talking of your remark, which would lead one to suppose that a portion of the water brought down by the main drain passed off by gravitation into the sea.

Captain TULLOCH—What I mean is this: in the town the rain will flow along the streets till it enters the main drain, by which it will be carried to Love Grove, where it will be pumped into the sea. The water falling on the rest of the island and collecting on the Flats would escape into the sea through the sluices.

Colonel KENDALL—But it is 5 to 8 feet below low water level, at level of 37. If you look at plan No. 4, page 34, you will see it so stated.

Captain TULLOCH—When the water from the main drain reached Love Grove, it would depend on the state of the tide whether any could be let out into the sea through the sluice; if the tide were low a good deal of the water could be let out. Suppose, for instance, that it were low water of low spring tides, the sea would then be at the level of 42·00, whereas the level of the water in the drain, if the latter were full, would be 47·00. Five feet of water could thus escape from the drain into the sea through the sluices.

Colonel KENDALL—Not from this main drain?

Captain TULLOCH—Yes; supposing, for instance, it is low water of low spring tide.

Colonel KENDALL—Are the existing underground drains mentioned in your report so laid that storm water will pass through them into the main drain without any further alteration?

Captain TULLOCH—Yes they can be connected with the main drain without much further expense.

Colonel KENDALL—Could you arrange the surface drainage of some of the streets above a certain level that they should pass off the storm water by direct route to the sea.

Captain TULLOCH—That could be done, but it would involve great expenditure, because we should require another system of drains separate from the present main drain, which answers every purpose. And this new system of drains should discharge into the harbour. There are three drains constructed already, which discharge into Back Bay, I believe. These are of great use, but would be independent of the new system of drains as suggested above.

Colonel KENDALL—But do you not think it is essential in dealing with storm waters that you should carry off as much by gravitation as possible?

Captain TULLOCH—Yes, if you can do it; but I don't think you can carry much off in Bombay.

Colonel TREVOR—Not in Bombay?

Captain TULLOCH—I do not think you can. I am speaking of the town.

Colonel KENDALL—Well, we are speaking of the town. It appears a serious defect that you have to pump up all the storm water.

Captain TULLOCH—Well, if you wish to do without pumping, you would have to put your drains down higher; but I do not see how you can do this.

Colonel KENDALL—What is the level of the sill of the sluices?

Captain TULLOCH—I think about 42. It is with the very object of saving as much pumping as possible that I propose raising the drain to the very utmost. I think the main drain will reach this at a level of 41.

Colonel KENDALL—Well, that would make a very serious change. It would entirely alter the whole project.

Captain TULLOCH—No, it will not alter it. The level of the bottom of the drain would still be 6 feet below low water of ordinary springs.

Colonel KENDALL—If you could avoid that, you would remedy one of the greatest defects. I see you increase the sluices very much.

Captain TULLOCH—Yes. But the sluices are for the reclamation of the swamps on the Flats.

Colonel KENDALL—With what object is that, if all the storm water is to be brought to Love Grove at a lower level?

Captain TULLOCH—But all the storm water does not; it is only the storm water which falls on the town, over an area of about 2 square miles.

Colonel KENDALL—But then, how could you limit the water from the higher ground from flowing into this main drain ?

Captain TULLOCH—Why should it go into the main drain ? The man-hole openings will be above the level of the Flats. I do not understand how any water could get into the drain except by the subsidiary drains in the town, which are intended to let the water into it.

Colonel KENDALL—How do you propose draining the Flats ?

Captain TULLOCH—By these sluices, and by pumping in very extraordinary cases (perhaps once or twice in the year), when great storms occur and we cannot let the water run by gravitation into the sea. A tremendous quantity of water gathers on these Flats. On the 9th August, I drove with Mr. Crawford through the town. We were in Mr. Crawford's brougham, and when Mr. Crawford got out the seat which he had just left floated, and I was in water up to my waist sitting in the brougham. And that was in the town. The water is at a much higher level in the town than on the Flats. Three feet higher it was on that day and the water could not escape.

Colonel TREVOR—That was due to the size of the drains, I suppose ?

Captain TULLOCH—I never saw a town under water like that in all my life.

Colonel TREVOR—Yes; it was a heavy shower.

Captain TULLOCH—The water was just within an inch of the greater number of the shops—in fact many of them were actually under water. We were wading in water up to our waists.

Colonel KENDALL—You say you arrange for the storm water which falls on the Flats being led off by gravitation through the sluices. I do not see what difficulty there should be in having the water falling on the higher ground dealt with in some other way rather than being taken by the underground street drains.

Captain TULLOCH—You could do otherwise, if you were content with surface drainage. I daresay I shall be laughed at for it, but before I went home I proposed to myself that all roads should, instead of being built (as now) concave, should be built convex, and that these roads should be your surface drains for the town ; and if you adopt that system in Bombay, I think it will be successful.

The CHAIRMAN—It has been adopted on part of the Malabar Hill road—between the Bee Hive and the Wilderness.

Captain TULLOCH—The strange thing is, that when I went to Europe, in the first town I saw which was Messina, the largest street was built like that. Half the streets in Rome are built like that and so also in Florence and Turin.

The CHAIRMAN—And with what result ? The most abominable stench. The entire filth of the neighbourhood accumulates in the middle of the road.

Captain TULLOCH—But that is not due to the *roads being constructed in that way*, but to there being no system of removing the waste water and the solid filth. If you are not content with surface drainage, of course you must go to underground drainage, and you must allow about 3 feet from the top of the road to the top of the sewer, in order to render it perfectly safe for carriage traffic. Say another foot for the thickness of the sewer, there is 4 feet from the top of the road to the top of the sewer.

Colonel TREVOR—What is the object of all this calculation ?

Captain TULLOCH—I only mention this to show that the main drain would arrive at the coast at such a low level that you could not discharge the water into the sea by gravitation.

Colonel KENDALL—But what is the object of discharging storm water through underground channels ? Surface channels are all that is wanted, I suppose ?

Captain TULLOCH—Yes ; but you cannot have the water of the whole town running along two or three miles of streets on the surface of the roads as at present constructed, because the whole place, every street in fact, would be from 2 to 3 feet under water.

Colonel KENDALL—I don't know that.

Colonel TREVOR—Oh, no.

Captain TULLOCH—I speak positively. That is the reason why we have underground drains at present.

Colonel TREVOR—But when you have a water supply in a town, are not underground drains necessary to drain the subsoil.

Captain TULLOCH—I am talking not of sewage, but of storm water.

Colonel TREVOR—But I am speaking of underground drainage for the drainage of the soil. Are not such drains necessary when you have a large supply of water laid on ?

Captain TULLOCH—I think not for that purpose *in India*. A great deal of harm is done by

rendering the soil too dry in this country. There is a point beyond which if you go you do wrong. In damp weather I think you do right to take every precaution to render the atmosphere and soil as dry as possible; but in dry weather I think you do wrong to drain the subsoil too much. At least, as I understand the theory of Pettenkofer, it is that the lower the level of the water sinks into the soil, the sooner is cholera generated, and therefore I take it that in India it is wrong to drain the subsoil too much. It is a very strange fact that till lately (within two or three years), there has been no such thing as diphtheria in Bangalore, and for twelve years the water has been going lower and lower; and now, I won't say constantly but occasionally, cases do occur there of this complaint.

Dr. HUNTER—Diphtheria is said to be unknown in Bombay; I believe I saw a case at Parell two or three months ago.

Colonel KENDALL—You have not described in detail the channels by which rain water collecting on the Flats is led off to the sluices.

Captain TULLOCH—There need be no channels at all. I would lead it direct to the sluices by sloping the ground. That is the advantage of putting the sluices at Love Grove. You don't require any long channel, which would involve a large amount of excavation.

Colonel KENDALL—Would anything be gained by having additional sluices in the middle of the Vellard for letting off storm water?

Captain TULLOCH—Not a bit, so far as I can see. I have thought of it myself, but I think the sluices have been placed very judiciously at Love Grove.

Colonel KENDALL—Well, you have surveyed the place, and you are the best judge.

Captain TULLOCH—If I could have discharged the surface water into the sea without lifting it at all, *of course* I should have done so. But Mr. Aitken also proposes to *pump* the rain, and the mere fact that we are both driven to it should, I think, be some testimony of the fact that Bombay cannot be drained by surface drainage only.

Colonel KENDALL—You talk rather generally about the Flats being drained by gravitation through the sluices. You have not given us any clear idea what part of the water collecting on the Flats or low-lying parts of the town will go into the main drain, and what will go off by gravitation.

Captain TULLOCH—I could give you these facts at the next meeting. I will draw a plan showing exactly what portion will drain into the main drain, and what will drain on to the Flats.

Colonel KENDALL—I think that is very important.

Captain TULLOCH—I will take a note of it.

Colonel KENDALL—And about the quantity of the water likely to collect on ordinary occasions. What horse-power engines do you provide at the sluices?

Captain TULLOCH—I propose either three condensing engines of 150 horse-power each, or two high-pressure engines of 100 horse-power each; and two condensing engines of 150 horse-power each. These engines will work up to three times their nominal power. The condensing engines will be exactly like the Crossness engines, which do a magnificent duty. Mr. Thwaites showed me a diagram sent by his father of the engines in use by the Metropolitan Board, and I suppose they have been burning the same coals they use for all water works engines, viz., "screen" coal. These engines have been working the whole year round, and they have raised 75 million pounds one foot high by the consumption of 1 cwt. of coal. It is a magnificent duty. That is the *actual working* of the whole year round, and the engines I propose to get ought to work better still, for they will be larger than the Crossness engines.

Colonel KENDALL—Give us what they actually get out of these engines. Will the engines you propose to provide pump both the drains, the main drain and the main sewer, running full bore—quite full both of them?

Captain TULLOCH—Very nearly. I have explained that in the project. If the main drain was full it would be a tremendous flood, and in that case one engine would pump at the sewer and pump it dry, while three engines would pump at the main drain and nearly overpower it, or so relieve it that the town within 24 hours after the storm is concluded would be clear of water.

Colonel KENDALL—You don't give any calculations about the flow through the main drain?

Captain TULLOCH—I am generally charged with giving too many details. I thought in this report I would only give you what was essential. I can give you every information in detail if you require it.

Colonel KENDALL—I suppose you have calculated it all yourself.

Captain TULLOCH—Yes; very carefully. Here is a whole book full of calculations. I can give you the calculations for the reclamation of the Flats; it is a little difficult to understand, but if you like I will go into it.

Colonel KENDALL—Oh, no.

Dr. HUNTER—You propose utilising the sewage?

Captain TULLOCH—As I understand it, the sewage question, which is a very great one in the present day, consists in the removal of three things, and I think this is too apt to be forgotten. First, all the rain that falls on the town; secondly, all the water used by the inhabitants; and, thirdly, the excreta, and by that I mean both the urine and ordure produced by the people. Now let us take the case of Bombay. The rain-fall here is 75 inches in a year. It is impossible to say what portion of that exactly goes into the sewers. Some is evaporated, some sinks into the ground, and some goes into the sea; but if we assume that one-third is lost and the other two-thirds goes into the sea—(and that will be a very fair assumption)—we shall have 50 inches of rain, or say 48 in., or 4 feet in round numbers, to be disposed of by drains. That quantity of rain on two square miles, the area of the town, would amount in the year to 1,394 million gallons. The sewage, taking the population at a million people, and the waste water at 10 gallons per diem, would amount to 3,650 million gallons yearly. Then the excreta, consisting of urine and ordure, would be as follows:—The urine at 2 lbs. daily per head, would amount to 73 million gallons yearly; and the ordure, taking about a quarter of a pound per head per day, to 9 million gallons yearly.

The CHAIRMAN—Four ounces for adults, and two and a half ounces for all ages and sexes. That is what we were told the other day.

Captain TULLOCH—That makes my argument all the stronger.

The CHAIRMAN—It would be five-eighths of your calculation.

Captain TULLOCH—The proportion would be—rain, 1,394 gallons; sewage, 3,650; urine, 73; ordure, 9; or in round numbers the proportions would be—rain, 150; sewage, 400; urine, 8: ordure, 1; so for every pound of ordure that has to be removed, 400 lbs. of sewage has to be taken away. Those who think that the solution of the sewage question depends upon the removal of ordure or urine only will see that it is a very small portion of the question indeed. Here we have a mass of matter to deal with, and some people set about the question proposing to dispose of about 100th part of that matter, and think they have solved the question. At Bangalore there was a general impression that if ordure and urine were separated from the sewage, that the sewage would have no smell at all; but I have always maintained that it would be in a very few hours almost as foul as ordure and urine together. At Bangalore the authorities were opposed to me. The drainage of the Racecourse Barracks all centred in one large cistern, from which it was removed by carts. By the drainage I mean both the sewage and the excreta. It was proposed to separate the excreta—ordure and urine—and to carry these away by carts, and to let the rest of the sewage dribble along the ground and escape. I said it would never do, for if we did such a thing we should have to build the cistern again, and remove the waste water and excreta just as we did before. I was ordered to remove the cistern, and to separate the excreta from the sewage, and I did so; but after it was done, in another week there was such a smell from the waste water only that the whole place around it was a nuisance, and I was ordered to rebuild the cistern and to remove all the sewage—the waste water besides the excreta—by carts. I only mention that to show you that the removal of waste water which has been used for human purposes is almost as foul, at all events it becomes so in a very few hours, as urine and ordure; and if we are going to enter into the sewage question, we really must enter into it in a proper spirit. The necessity for the removal of all these things must be recognised—the rain, the sewage, and the excreta. Mr. Aitken said the other day that 50 per cent. of the excreta of Bombay goes into the sewers, and certainly from my own knowledge of Madras and of Bombay, acquired since I have been here, I should be quite inclined to agree with him. I think 50 per cent. certainly of the excreta goes into the drains, and in that case I don't see what harm there will be in letting the rest go in. You were just now on the question of gases escaping into the houses; I don't know whether you read the last letter of Mr. Rawlinson addressed to the authorities at home; but it is very important indeed. At present this is the system of house drainage. (Captain Tulloch here explained the system by a drawing.) Mr. Rawlinson says—and I think it is really a most important discovery—that the line of pipe from the house to the sewer in the street should be broken, in fact that there should be no pipe issuing out of the house; that the water should escape along an open channel for some distance, by three or four feet, from the house, and that there should then be a syphon trap,

and on the other side of that a ventilator. Now let us consider what would be the effect under that system. The gas from the sewer could not escape and come into the house.

The CHAIRMAN—The system is no doubt scientifically complete, but it would cost a fabulous sum if you wanted one of these for every house.

Captain TULLOCH—We should not want one for each house. With regard to the halalcore system, I agree with Mr. Aitken that the best plan is to remove the excreta by the sewers ; I don't think that any halalcore system will answer in the end. At present the nuisance is undoubtedly very great at certain times of the day and night. On going through the town about 11 o'clock P. M., the stench from the night-soil carts is really most dreadful; you observe the same thing in the morning about seven or eight o'clock. The smell from the sweepers' baskets is equally great; but letting alone the sanitary objections, which I think are important, and considering the question from an economical point of view, it is about the worst system you could have. I do not know the exact cost, but perhaps Dr. Lumsdaine will tell me. I assume that it costs about 5 lakhs a year. Mr. Aitken said the other day that in 1867 there was about five lakhs spent on it, and I understood him to say Rs. 4,85,000 had, in addition, to be laid out on the scheme. I do not know if that is the case ; but that is a capital of nearly two millions sterling. In addition to the two millions, or whatever it may cost really, you have got to provide a drainage system still ; whereas a complete sewerage system will not cost more than a million sterling. I don't mean to say I advocate water closets just as in England, but water closets with some modifications might be introduced. The excreta now remains in the town for many hours (12 or 15 during the day), but with the water carriage system it would not remain more than five at the outside, and the greater portion not three. With two millions sterling you might not only have a drainage system, but another water supply too.

The CHAIRMAN—Your scheme of removing the sewage by water would of course necessitate an increased water supply ; the rain-fall is limited only to a few months; and seven or eight months we have no fall at all.

Captain TULLOCH—No rain would go into the sewers.

The CHAIRMAN—But if you carry away the excreta by water, you must have an increased water supply ?

Captain TULLOCH—No ; I don't think so. I find on looking at my notes that the halalcore cess yields the Municipality 5 lakhs, and there has been 2½ lakhs set aside for drainage works, and there is the cost of repairing the drains and sewers, which comes to 1½ lakh a year, making altogether a total of about 9 lakhs, which represents a capital of nearly two millions. If that were applied to drainage and water supply, there would scarcely be any tax at all required to be imposed on the town except the present halalcore cess. I have got a few notes on the dry-earth system, and I wish to show how impracticable that is in Bombay. I have considered the system for six years, and I will show you the impracticability of it in Bombay. The greatest advocate of it is Mr. Moule at home. He says that one ton suffices for 1,000 uses. Suppose each individual goes once a day to the water closet, and suppose that the population is a million, it is quite clear that 1,000 tons of earth must be brought in and taken out of Bombay every day. Besides that, the excreta at 2½ lbs. daily would amount to just another 1,000 tons, so that altogether the total quantity of matter that would have to be removed out of the town would be 2,000 tons. If you allow a cart to carry half a ton, and it makes three journeys per diem a distance of two miles, that is altogether twelve miles in a day, you would require 1,300 pairs of bullocks at least. I don't know what you can get a cart with bullocks for in Bombay, but the cost is Rs. 45 a month.

The CHAIRMAN—I don't think it costs the Municipality that sum.

Mr. AITKEN—They are about Rs. 1-2 a day.

Captain TULLOCH—Say then Rs. 35 a month. You would require to spend about 5½ lakhs a year, which again would represent a capital of nearly a million sterling at six per cent. This is for nothing but bringing in the clay and taking it out; no cost of latrines, or urinals, or sheds, or land for establishment.

Colonel TREVOR—Do you include railway carriage in this estimate ?

Captain TULLOCH—No. I am supposing you can get the earth two miles from Bombay—it is a very absurd supposition, but just supposing you could get it so near. I have calculated what it would come to, and it is a million sterling. If you went carefully into the cost of the dry-earth system, you would find that it would require a capital of from two to three millions sterling for Bombay.

The CHAIRMAN—Then you don't allow for drying the earth in the monsoon; you would want kilns and an immense establishment?

Colonel TREVOR—You have very much under-estimated the cost.

Captain TULLOCH—Yes; I know I have.

Dr. HUNTER—The carts alone would cost more than six lakhs a year; but apart from pecuniary consideration, we are under peculiar circumstances in Bombay, having a rain-fall of 75 inches in four months. The habits of the people, too, must be considered—ablution after defæcation—which you cannot revolutionize, however desirable it may be to do so.

Captain TULLOCH—The cost is something frightful, and that which astonishes me is, that a man like Mr. Blaney should go in for the dry-earth system without putting anything definite before the public. If you collect facts regarding the cost of this system in hospitals and military establishments where it is used, it would be found to be something tremendous. It is only Government who can carry out such a system. For towns it is impossible. If you brought the earth in, how could you see it distributed? When I was at Bangalore at the Race Course Barracks, there were privies upon the dry-earth system, and the Colonel of the Regiment could not get the men to throw sand into the closets after uses, although it was placed most conveniently for them. He told the sergeant at last to put the first man he saw neglecting to throw clay into the closet as a sentry at the place till he caught another man failing to do the same thing, who was then to relieve the first from the duty. If that is so in an establishment where the discipline is so strict, what would take place in the native town—and who could ever see that clay was being used by the inhabitants?

Colonel TREVOR—We don't want much proof of the impracticability of the dry-earth system.

Captain TULLOCH—I don't know if you want me to go into Liernur's system?

The CHAIRMAN—No; I think not.

Captain TULLOCH—In regard to open drains, I went to Berlin to see the system of open drains there, and the first question the engineers asked me was, "Why have you come here?" I said, "To see your system of drainage;" and they said, "This is the worst drained town in Europe." There they have a system of open drains, an improvement on the drains here, but it does not answer, and they want to fall back on the English system, so that those who say that we can get over the difficulty by improving the present drains are altogether wrong. I am sure no system of open drains will ever succeed, for you can never prevent people throwing solid matter into them. Liernur's system applied to Bombay would cost 3½ millions, according to his own statements. With regard to irrigations, I may say that it is now almost the unanimous opinion of engineers that the utilisation of sewage is the greatest step ever made towards the solution of the drainage question. Wherever you go, in all parts of England and Scotland, that theory is being accepted. Now Mr. Aitken, the other day, quoted some figures of Mr. Latham's, and I only wish Mr. Latham was here now. I believe if there was any land within 20 miles of Bombay, or even any land beyond, that Mr. Latham would go in for sewage utilisation; he is the greatest advocate of sewage utilisation in England, and wherever he goes he advocates it.

Mr. AITKEN—I did not cite Mr. Latham as an opponent; I took his figures to show that a certain amount of land was required.

Captain TULLOCH—Mr. Latham is so satisfied that sewage utilisation is practicable, that he has introduced it into very many towns. I am almost certain he is the engineer for the Birmingham works. Mr. Aitken also gave some information regarding Birmingham from books, and there again I say he is wrong. They have never used sewage at Birmingham, at least they had not when I left. What they have been doing is this. They have been throwing solid sewage into great heaps ten feet high, and there were many acres of ground covered with it, and the idea has been that they have been utilising it. They have been keeping it for people to buy, but the farmer's won't buy it. But sewage utilisation, if you apply the term to such a system as that, is a failure; they were however preparing the ground for a new system. In Paris the French engineers are most enthusiastic about it; they have a little farm of about 5 acres, and they grow everything on that with the help of the sewage. All over Germany they are advocating it, and in Italy just the same. In fact, the general voice of engineers in Europe is in favour of sewage utilisation.

Dr. HUNTER—Is not that under certain restrictions? In Germany and Austria they do not allow it within a certain distance of a town.

Captain TULLOCH—I quite agree with you that sewage should not be used in the immediate neighbourhood of the town. The further you go in moderation the better, but there is a point beyond

which it would be a waste of money to go without good reason. I believe in the northern portion of the island you might use the sewage with perfect impunity. I don't object if you take the sewage out of the island. I should be delighted if that were carried out. There is a magnificent tract of country towards the north where you can get 10,000 acres if you want them.

Colonel TREVOR—Yes; by reclaiming it.

Captain TULLOCH—Part would have to be reclaimed.

Dr. HUNTER—I understood you to say that there was land about eight or nine miles off.

Captain TULLOCH—Nearer than that. With regard to the quantity of sewage which one acre will suffice for, in England it is generally assumed that one acre will do for 150 people, but that is with a water supply varying from 30 to 40 gallons per head per diem, which here you would never have with your imperfect distributing apparatus. There will not be more than ten gallons per head per diem entering the sewers for years to come; therefore, if in England there are 30 gallons per head per diem, and one acre is sufficient for 150 people, here it will do for 450 at 10 gallons per head. At home the rain is taken in with the sewage, and of course the land cannot take up as much sewage, in proportion to the population. Here we propose to separate the rain from the sewage, in which case an acre will, I am certain, do for 500 people. And then again there is the evaporation and dryness of the soil here to be allowed for.

The CHAIRMAN—Then you would want about 2,000 acres, taking it at one acre for 450 persons.

Captain TULLOCH—But I believe the soil here will take up three times the amount it will at home

Mr. AITKEN—But will the plants take it up?

Captain TULLOCH—How many crops can you get in this country as compared with what you can get at home? Now it is very well known that during the summer months the plants will take up more than in the winter months, and here with this dry soil they will take up three or four times as much as that; I believe that one acre will suffice for 1,500 people at the least. I mean so that there shall be no nuisance at all. I don't mean to say that what I have estimated is quite sufficient for the sewage for the future wants of Bombay. What I think is that that is quite sufficient for the Municipality to take up at present. I would have them use the sewage on as much land as possible, but there would be a great number of private persons who would use it on their land, so that the Municipality will be quite independent of the people. For the next fifteen years, 400 or 500 acres would be desirable.

The CHAIRMAN—But if the people themselves will use the sewage, what will be the use of the Municipality taking any part of it?

Captain TULLOCH—I should be very glad if the Municipality took none at all; I think that is the best system; although when I recommended the other, in my project, it was against my own judgment.

The CHAIRMAN—Then I understand you not to include in your scheme the *taking* up of any land by the Municipality for sewage utilisation?

Captain TULLOCH—I have included the cost of the land in my project, but I think it would be much better if the Municipality continued their experiment on a larger scale, so as to convince the landed proprietors that it is a right thing to cultivate their land by the aid of sewage. There is no doubt when a man's interest is in the land, he will work it well; it is only human nature that he should do that.

The CHAIRMAN—Is it not a fact that the sewage utilisation scheme at Barking ruined the company started for the purpose of utilising it?

Captain TULLOCH—No; I don't know that that is so.

The CHAIRMAN—Apart from the sanitary point of view, do you think you have sufficient experience to warrant the Commission taking it as a fact that the utilisation of sewage will pay?

Captain TULLOCH—Yes; most emphatically. I think I may say I know almost every farm that is worth knowing in England where it has been adopted, but you must not expect large profits *all at once*. There was an argument Mr. Aitken used the other day against irrigation, that fever is caused by irrigation. Now, if that is really the case, I think where we should find it would be the delta of the large rivers, such as the Khistna; but it is a fact that there is no such thing as fever there.

The Commission then adjourned.

TENTH DAY, FRIDAY, APRIL 30.

The following Commissioners were present :—

ANDREW R. SCOBLE, Esquire, *Chairman.*
Colonel KENDALL, R.E. | Lieut.-Col. TREVOR, R.E. | Dr. HUNTER.
Dr. LYON, *Secretary.*

The Commission resumed at 2 o'clock on Friday, in the Durbar Room, Town Hall.

MR. THOMAS ORMISTON, C.E., *was first examined :—*

The CHAIRMAN—Have you considered the project by Captain Tulloch for the drainage of Bombay ?

Mr. ORMISTON—I have read Captain Tulloch's report, though I cannot say I have considered it more than I have considered all other schemes of drainage that have been proposed ; but I am willing to explain to the Commission, as far as I can, what my connection with the drainage of Bombay has been, and what my views on it are—if that is what you want.

The CHAIRMAN—Yes ; that is what we want.

Mr. ORMISTON—I came to Bombay at the end of 1864, and, as the Commission is aware, my appointment was engineer to the Elphinstone Reclamation Company. Shortly after I arrived I met Mr. Bulkeley, Executive Engineer for Drainage at the time, who told me he would shortly require a site for a pumping station at Warree Bunder, with large engines. It seemed to me that it was a pretty large scheme, and I asked him about it. Some time after that a gentleman, staying with Sir Bartle Frere at Parell, went over the works with me. We talked about drainage matters, and I told him that if they were to have such an extensive pumping arrangement as Mr. Bulkeley had spoken of, it would be better to send the whole of the sewage to Colaba, and have it taken away as far as possible from Bombay. I presume he had mentioned that to His Excellency Sir Bartle Frere, because some time afterwards Colonel Kennedy asked me what my views were as to the drainage of Bombay, and you will find these in a note which I made, dated 22nd April 1865. This was afterwards further extended in another Memo., dated 4th December 1865. It was mainly with a view of getting, as I supposed, a better arrangement than was at that time proposed to be carried out that I suggested Colaba. I held at that time very much the same views as Colonel DeLisle did with respect to the plan then being carried out, and which I understood was Wilcox and Tracey's. Colonel DeLisle stated that to drain Bellasis Road and neighbourhood of sewage and storm waters 850-horse power would be required, and if the Flats and other low-lying ground in the neighbourhood was added, from 2,000 to 3,000, and that there was a danger, in case of the derangement of the machinery, of the town of Bombay being flooded with diluted sewage. Seeing that these were the proposals, I strongly recommended that observations should be made to ascertain how the harbour currents acted. Working it out roughly, I found that if the rain was separated from the sewage, a less amount of pumping power would be sufficient to take the whole sewage of Bombay to Colaba than to drain simply a portion of the town of surface water and sewage water combined. There has been a very considerable amount of discussion on that point, as you are aware. Mr. Aitken produced his scheme, which was practically what I had proposed, and I consider, if money were no object whatever, it is probably the best thing that could be done. The great difference between his scheme and Captain Tulloch's is, that Captain Tulloch takes his drainage to the north instead of the south, and that he proposes to utilize the sewage. If

there were no sanitary objection to it, Captain Tulloch's outfall at that end of the island would be the better one, because it is the way the surface water naturally tends—though not to such an extent as to cause one to depart from where the best outfall should be, which I consider a primary point to look at. I confess that I have changed my mind a good deal on the propriety of carrying out an extensive system of sewage in Bombay, and I now agree with the recommendation of Dr. Hewlett in his report to the Bench on Mr. Aitken's scheme. He says—"Although perhaps rather exceeding the limits of the subject on which I was called upon to report, I would in conclusion advise H. M.'s Justices to be content for the present with a thorough improvement and reorganisation of the *surface* drainage throughout the city." My views on the subject are simply these—that we should improve the surface drainage, and that we should put more water if possible into the drains; so that the sewage which gets into the sewers will be more diluted than it is now; and that we should, as we do now, keep the excreta as much as possible out of the sewers. That is done at present to a large extent—to a greater extent than it has been for many years past. Some improvement is necessary for the disposal of that stuff; if it could be economically converted into *poudrette*, I think we should be as nearly perfect as we can expect to be. With respect to the sullage and surface waters, I should allow them to take their nearest natural outfall, either into the harbour or to the other side of the island. I am less afraid now than I was at a former time of polluting the harbour, more thoroughly understanding the advantages which we have here by the diurnal variation of the tide, which I may explain is something like this. Supposing the harbour were a box, and the depth in it at a morning high water 36 feet, then the next low water would lower it to 30 feet, and the following high water it would rise to 38 feet, or 2 feet higher than the previous one—so that we have 2 feet more water from outside, and taking the proportion of 2 feet to 38 feet, it is 5 or 6 per cent. of the whole. That is a large proportion, and on such an area as we have here, has, I believe, been the real cause of our harbour being comparatively so pure as it is. Sewage being lighter than salt water, this condition of the tide involves a considerable expulsion of the sewage every twelve hours. The principal reason why I should not wish to see night soil going into the sewers is from the fears that have been expressed by medical gentlemen that there would be gases emanating which would prove unwholesome, and would breed diseases at present unknown here. With respect to the utilization of sewage, which is the main point of Captain Tulloch's scheme, I have to state that I had considered the subject as applied to Bombay two years ago, in answer to a Government resolution, dated 26th June 1867, in which Government reflected on a drainage committee, of which I was a member. As a member of that committee, having given a large portion of my time to Government, and done my duty as I supposed, I felt rather aggrieved at the tone Government assumed in their resolution, and I wrote a letter to Colonel Kennedy on the subject. The first part of that communication is of no public interest, but the latter part of it bears on the utilization of sewage. It was considered by me at that time at the request of His Excellency Sir Seymour Fitzgerald, and I will now read what I said then, and if the Commission will allow me I will put it in.

The CHAIRMAN—We shall be very much obliged.

Mr. ORMISTON—Then read and put in the following :—

"It may be thought proper to consider whether the circumstances of Bombay are not such as to make it possible economically to utilize its sewage, a principle which has been much advocated for the last 30 years, and is now applied with success in certain favourably situated localities.

"This may be done in at least two ways, either the excreta may be converted into *poudrette*, or the sewage may be used irrigationally.

"There is perhaps no place where the former system could be tried more readily than Bombay so far as the mere collection of the material is concerned; the halalcores would only require to carry the stuff to the Flats or whenever the manufactory was placed, instead of to Chinch Bunder, as they do now.

"The experiment may be worth making, but I question its economical success; I rather think it has so failed at home, where both the material to deodorize it and the fuel to dry it are very much cheaper than they are here.

"There are others which may perhaps be fairly called 'fancy' systems, which are advocated for disposal of the night-soil, such as by 'dry earth,' 'vacuum tanks,' &c.; but, however possible it may be to experimentalize with these for a small community, I fear that the extent of this city precludes any chance of success; the Paris system of cesspools would no doubt be workable, but it would perhaps be found to be more objectionable in this climate than even the halalcores are; besides neither of these systems would dispense with the necessity of sewers for the sullage of sinks and bath rooms.

"The irrigational system has been more successful, notoriously so at the Craigentinny Meadows, near Edinburgh; at Croydon, and at Mansfield; but these places are small and manageable as compared with Bombay, and they have also, I believe, porous subsoils, the most favourable for its application. The question was fully discussed at a meeting of the Institution of Civil Engineers in 1848, and though the system has been to some extent developed since, much of what was advanced then still holds true. Mr. Peto, M. P., said 'he trusted that such a nuisance as spreading liquid manure over

the land near London would never be tolerated; he was well acquainted both with the Meadows near Mansfield and near Edinburgh, and must say that, however great might be the agricultural advantages of the system, it would be dearly purchased if the whole region near any town were infected like the two places he had named.' At the same discussion Mr. Wickstead stated 'that one acre of land could take 12 tons of sewage per annum.'

"But even if it were in a sanitary point of view without objection, the area of land required for such a population as we have to deal with, and the cost of applying it from a low lying city, are serious matters.

"I estimate that the quantity of sewage to be disposed of may within another generation amount to 178,535 tons per day, which would, according to Mr. Wickstead's theory, suffice for over five millions of acres; this looks absurd on the face of it. I have therefore calculated what it would require, agreeably to a high authority on Indian irrigation, Colonel Strachey, R.E. He says that a constant flow of one cubic foot of water per second will irrigate about fifty acres of land, which is equal to half an inch over that area per day, a quantity which appears to me to be quite as much as should be run over it on the average. At this rate, therefore, it would take 3,700 acres, or nearly six square miles, to utilize the sewage of Bombay; an area which is just one-third that of the whole island.

"The area I have named is about equal to the whole of the island north of Parell, and I will endeavour to show how it would work out even if the whole of this space were available and suitable, or if it were proper to apply it so near the city, both of which positions I know are quite untenable; but to whatever greater distance it be removed the expense of the Main Drainage proper would be proportionately increased and the cost of utilization would not be lessened.

"Parell House is situated about the same distance north of the centre of the City Drainage that Colaba is south, viz., four miles; the centre of the supposititious irrigated district is about two miles further.

"It would thus appear that to discharge into tanks in the centre of the nearest land would, as compared with Colaba, involve two miles longer of main drain, and therefore 4 feet or about 12 per cent. of extra pumping; but as there would be sea works and perhaps rock cutting saved, it may for our present purpose be assumed that the cost of the main drainage proper would be the same whether the sewage be discharged into tanks at Colaba and wasted, or into tanks at Matoonga and utilized. To save pumping at any outfall as well as for the economical construction of the works, one would properly have the outfall works at the lowest level possible, so as to reduce the lift of the sewage to the minimum; the tanks would in any case probably be not much above high water mark; thence it would be necessary, if it be utilized, to force it up to the surrounding districts so as to dominate the sections it was intended to irrigate. It is not in the least likely that any district of the required extent could be found in which this would be less than the lift of the sewage from the sewer to the tanks, and if so it is clear that it would take as much power. Again, it would not be safe to flood the land to the required extent unless it were thoroughly drained either naturally or artificially: that the latter would be necessary is probable, as Mr. Wyne, in his account of the geology of the island, says, 'None of the recent strata of the island seem to be particularly porous.' To spread sewage over such an extent of undrained area and without perfect natural drainage would in this climate be an extremely hazardous operation.

"To test it, however, from an economical point of view only, it will be near enough if we assume the following figures as a rough estimate of the capital cost and annual charges for distributing the sewage, after it is deposited in the tanks, by the pumps of the main drainage proper:—

Engines 500 H. P., pumps, boilers, and buildings	£50,000
Distributing pipes and drainage, 3,700 acres, at £4	14,800
Capital cost (say £60,000)	64,800
Interest and sinking fund, 7 per cent.	£4,200
Depreciation	1,500
Coals	19,200
Wages and stores	2,500
Annual charges	£27,400

which is (£7 10 or) 75 Rs. per acre.

"From Colonel Stratchey's report on Sind, I gather that Rs. 5 per acre is a good rent for water supplied for irrigational purposes, and if we assume that the application of sewage would increase the yield eightfold, a result which a farmer near Tipton told Mr. Mechi he had attained by the substitution of sewage for water irrigation, and which the worthy Alderman published as a wonderful result, it would give little better than half the rent required."

Mr. Ormiston proceeded—I don't think sewage applied to the land would be wholesome, and I think there would be a disagreeable smell, and also that it would not be so profitable as the advocates of it assume; nor do I believe it would be so readily taken for irrigational purposes as pure water would be, and the latter could probably be supplied for irrigation cheaper by gravitation than sewage could be pumped up. As to the difficulty Mr. Aitken fears in separating surface water from sewage, I think he has exaggerated that, and I am of opinion that the plan and report he has prepared to prove his case show there is no difficulty at all. I think Captain Tulloch's remarks on that are very reasonable and sensible, and dispose of it sufficiently. If that is the only difficulty, I don't think it should be entertained. There may be low-lying districts which it would be impossible to drain perfectly except by pumping, but I think the surface water of the whole island gets off in a tolerably fair manner, and I would simply allow it to do so, improving it as much as possible from time to time by adopting such measures as have been so successfully introduced at Cammatteepoora. An entire change has been wrought in that district by what has been done during the last year or two.

Mr. AITKEN—That is rain water and sewage combined.

Mr. ORMISTON—It is.

Colonel KENDALL—Do you think it is unavoidable to let the rain water into the underground sewers in most parts of the native town ?

Mr. ORMISTON—Wherever I could get rainfall to go away by gravitation, I would certainly let them go together.

Colonel KENDALL—But that is not the case. The present plan of Captain Tulloch is to let all this sewage into the main sewers, and to bring that down to Worlee, where it will be pumped up. That is Captain Tulloch's plan.

Mr. ORMISTON—I don't like that.

Colonel KENDALL—Do you think an arrangement might be made by which the rainfall would go off by gravitation ?

Mr. ORMISTON—Yes; as it does now. I don't see any objection to the present system being retained—of pumping as much sewage as you can at Love Grove—and as that is in the neighbourhood of where Captain Tulloch proposes to have his engines to pump the sewage for utilization, I think it would be very proper to continue and enlarge the experiment Mr. Crawford is now making there.

Colonel TREVOR—Captain Tulloch means to keep the pumping station there, but not to utilize the sewage there.

Mr. ORMISTON—Well, as you have pumps there, instead of pumping into the sea, I should pump it on the land. I must say I should be delighted to find it advisable from a sanitary and economical point of view to utilize the sewage here. It would be a very fine thing, but I heard Dr. Hunter the other day give what appeared to me to be a very solid objection to it. If it can be done economically, I think that is a very good place to try it; but I should strongly advise the Municipality not to go in for a great scheme for carrying out any large system of sewage which requires pumping at all. I am inclined to believe that the island of Bombay could be effectually or nearly effectually drained by gravitation, and I would rather wait for some time and endeavour to induce the people, by assistance or otherwise, to raise the ground which is at present too low to be drained by gravitation. It is not a large area, only 170 acres altogether.

Colonel KENDALL—And you think that in Captain Tulloch's scheme there would be no necessity for carrying his main sewer at such a low level as he does, between 5 and 8 feet below low water ?

Mr. ORMISTON—Well, you would probably get Captain Tulloch to explain his scheme himself.

Captain TULLOCH—I am ready to explain it here.

Mr. ORMISTON—I disapprove of any great scheme for utilizing the sewage, or making any great system of sewage with its outfall at the north end of the island, until it is thoroughly established that utilization of sewage is satisfactory. I think it would be a great mistake to take the sewage there with the prospect of eventually requiring to send it back by a pipe to Colaba.

The CHAIRMAN—Do you not think that a great deal might be done by improving the surface drainage and the halalcore system for the removal of the night-soil ?

Mr. ORMISTON—I think so; and I say the expense of large pumping power is a very serious one in this country. I take the liberty of reading some remarks out of the communication to which I have already referred on the cost of pumping in Bombay :—

"It must be borne in mind that, under any circumstances, there will be some percolation of rain water into the sewers during the south-west monsoons, when the ground is saturated. I think it is quite enough to have to pump that in addition to the sewage without purposely admitting the rainfall.

"The increased power required for pumping both sewage and rainfall as compared with sewage alone, is strikingly exemplified in the change which was introduced into Messrs. Wilcox and Tracy's proposal after the executive had passed out of their hands; their low level or pumping area was for a prospective population of 630,000, and they estimated that 150 horse power would be sufficient, but, to make provision against accident, recommended 300 horse power to be supplied.

"Mr. Tracy died, however, and the execution of his scheme passed into other hands: why or by whom it was altered I am not aware, but it is clear that Mr. Bulkeley contemplated admitting the surface waters, and this involved an immediate rise to 850 H. P., with the prospect of ultimately requiring as much as two or three thousand horse power.

"When it is considered that coal in this country generally costs sixty shillings per ton, which is from three to eight times the cost at home, every possible attempt should be made to lessen the quantity required.

"It is also important to remember in connection with this subject, that coal in this climate does not do the same duty, weight for weight, which it does at home; a large portion of the gases escape through time by exposure.

"Mr. Proud, Manager of the Bombay Gas Works, tells me that his experience shows that coal, stored in a dry state under cover in Bombay, loses from 5 to 10 per cent. per annum of its volatile properties; if stored under cover in a wet state, 25 per cent. at least; and that uncovered it loses 50 per cent. per annum of its value for gas purposes, and for steam purposes nearly as much.

"The following table shows the consumption of coal at three of the larger Spinning and Weaving Mills here, by which it will be seen that the most favourable result gives 18½ tons per annum per actual horse power of an engine constantly at work, and 36 tons per nominal horse power:—

Mills.	Kind of Engines.	No. of Engines.	Nominal H. P.	Actual H. P. working up to in July 1867.	Total.		Tons of Coal consumed in 12 hours.	Pounds of Coal per Hour.		Tons per Annum if Constantly Working.	
					Nominal H. P.	Actual H. P.		Per Nominal H. P.	Per Actual H. P.	Per Nominal H. P.	Per Actual H. P.
B.	High Pressure	1	40	90	100	270	9	16·8	6· 2	65·6	24·2
	Do.	2	30 each	90							
A.	Do.	2	60 „	140	120	280	9	14·0	6· 0	54·7	23·4
O.	Compound, average ...	2	80 „	150	160	300	14	16·0	8· 0	62·5	33·2
Ditto	Ditto (Best result)	...	...	...	...	...	...	...	4·75	36 (about)	18·5

"In these cases I believe the coal was stored uncovered, but if we make an ample allowance for having it covered the result would still be 16 and 37 tons per annum per actual and nominal H. P., respectively.

"It may be here stated that the nominal horse power of the London Main Drainage is 2,318, and Mr. Bazalgette estimates the consumption of coal at 44,000 tons per annum, if at full work day and night, which is 19 tons per nominal horse power per annum, as against 36 tons under favourable circumstances in Bombay—a startling difference.

"Mr. Aitken estimates that 400 actual horse power would be required during the fair season for Bombay. I do not think it would be less; but even this power would take at least 6,400 tons per annum, which at £3 amounts to no less a sum than £19,200. There can be no doubt that coal, oil, wages, and repairs would absorb the whole sum at which Mr. Aitken estimates the annual expenses of his system.

"I dare say it is *easier* to design a system of drainage which includes in one set of sewers both surface and sewage water; but this is not a sufficient reason for abandoning a correct principle, and one that must be ultimately more economical and at the same time safer, for, as Colonel De Lisle observes, at any time a derangement in the machinery during heavy rains would flood Bombay with diluted sewage.

"I must not be understood to object to overflows at all; these I have from the first considered ought to be provided. It would be monstrous to make no provision for an accident to the machinery or for a failure in the supply of fuel."

From inquiries which I have made I believe you will find that you do not get more than two-thirds as much out of coals here as you do at home, and I think the quantity which Captain Tulloch has put down for pumping power—three tons per diem of 24 hours—is absurd.

Captain Tulloch—That is exactly what I have taken—two-thirds of the duty got out of the Crossness engines.

Mr. Ormiston—But you say three tons. Now I think that is an absurd amount for large engines working 24 hours a day. You will find that the duty that you will get in Bombay is not more than I have said—you require at least 18 tons of coal per horse power per annum—*actual* horse power, not *nominal*. Nothing varies so much as the duty of engines, and I think Captain Tulloch has taken too favourable an estimate of the coal which will be consumed.

Captain Tulloch—If you look to page 30—and Mr. Thwaites will bear me out—you will see that the Crossness engines lift 75 million gallons one foot high with one cwt. of coal. They have been doing that last year, and I have taken two-thirds of that—and that is just what should be taken—and that would be 50 million gallons one foot high with one cwt. of coal.

Mr. Ormiston—What power of engines are yours?

Captain Tulloch—Two of 150-horse power, and two high-pressure engines of 100-horse power. each—that is 500-horse power.

Mr. Ormiston—And do you expect to work that power with three tons of coal a day?

Captain Tulloch—I am not going to work it the whole of the day. You don't want that. There is a certain amount of water to be raised, and it shall only work sufficiently long to get rid of that.

Mr. Ormiston—With respect to that you will find in the report I have handed in a table, showing the result of enquiries as to the actual consumption of coal by Hick's engines in Bombay, and they are supposed to be the most economical in that respect which are made—it varies very considerably. But the *least* is 18½ tons per indicated horse power per annum. The book I hold in my hand is "Hughes on Water Works," and it contains tables showing the duty of numerous engines, and that they vary very much—say from 105 million gallons raised one foot high with one cwt. of coal down to 70, 35, 27

million gallons, and so on; and the average duty of Cornish engines, taken from *Lean's Engine Reporter*, is 53 million gallons raised one foot high by one cwt. of coal.

Captain TULLOCH—I have taken 50 millions.

Mr. ORMISTON—Well, I think that is much too little. I know what the working of engines is, and I cannot conceive 300 or 400-horse power, working continuously, with three tons of coal per diem. How much do you consume at Love Grove?

Mr. AITKEN—It used to be five tons.

Mr. ORMISTON—With how much horse-power?

Mr. AITKEN—21-horse power developed.

Mr. ORMISTON—Well, that is the result of actual practice.

Mr. AITKEN—The engines are very bad, however. I think we could do it with three tons.

Mr. ORMISTON—I am quite satisfied that you could not work three large engines with three tons of coal per day. You will not get it here. Captain Tulloch's arithmetic is quite correct. I admit that. I don't know if there is anything further you wish from me, Mr. Chairman.

The CHAIRMAN—Can you give us any information as to the tank and the pipe that carries the sewage from the tank into the harbour?

Mr. ORMISTON—The pipe is laid under the overbridge and the railway in a curved line through rock-cutting as far as the bunder. If it were necessary to open that trench again it might be done, but it would take some time. The pipe has been gradually filling up, and is now for at least 300 yards in length found to be choke full of sand, tiles, brickbats, and rubbish. It has been cut open at the Arthur road drain, into which the filth is at present being discharged as a temporary expedient, and through it into the harbour. Whenever the Health Department chooses it may now let it go into that drain. Though I have not yet spoken to the Commissioner about it, I think it would be worth while considering whether it may not pass into this drain (instead of restoring the pipe); this would involve a large quantity of water being discharged into the head of the drain at the same time, but it would save the nuisance of the pipe being choked up. * At present the pipe seems certain to be choked up every year, for it has not yet been a year in operation.

The CHAIRMAN—How do you account for bricks and such stuff getting into the drain?

Mr. ORMISTON—They say that the Bhunghies get so much a trip, and gather all kinds of stuff into their baskets and tip the whole into the tank. I don't know whether there is anything in that or not, but certainly that is a way of accounting for it.

Colonel TREVOR—Such stuff would find its way into every drain.

Mr. ORMISTON—Every drain should be so large that a man could get into it to clean it. That is what we have in the Elphinstone property. The smallest of our drains is 3 feet 3 inches by 2 feet 3 inches. We have already four miles of drains, and these are intended to take sewage and rain water and whatever comes into them, but I have always looked forward to keeping out the night-soil as much as possible. That is the system which has been carried out in Paris in a very effectual manner. I put in a pamphlet for the use of the Commission. It contains the results of enquiries in Paris by a deputation from the Glasgow corporation. I think you might do worse than request Dr. Hewlett to make himself fully acquainted with La Villette—the Paris night-soil depot—to see how far it may be adapted to Bombay. It appears to receive about two thousand tons of material every night (midnight to 7 A.M.), brought in casks and tipped into large tanks, where it is manipulated by being made to pass down trays at certain slopes: even the urine is kept out of the sewers as much as possible, and is also brought to La Villette, whence it is sent through a pipe to Bondy, some 7½ miles from the depot. At Bondy it is converted into sulphate of ammonia, for which they get from £4 to £6 per ton, and they make five or six tons daily. The solid matter is carried to Bondy principally by a canal, in casks and in boats, and made into *poudrette*. Hitherto that has been a profitable manufacture, but the contractors do not seem to have cared much for it lately, and the Glasgow committee were doubtful whether it would continue to pay as well as it had done. I put in this pamphlet, in which I have underlined the parts having reference to this subject, and I think you will find it worth reading. As to what is admitted into the sewers they say:—

"It must here be explained, however, that the system of sewerage above described is chiefly intended for the removal of the surface-water, and of certain kinds of liquid refuse permitted by the regulations to flow into them from public works, baths, and wash-houses, &c. Great care is taken

* NOTE.—A fortnight's trial of this expedient has proved that it would be dangerous to continue it.—T. O.

throughout the city to prevent the discharge into the sewers of all decomposing matters in quantity, or other matters liable to contaminate their contents; and, in particular, those excrementitious matters which in this country are more especially associated with the idea of sewage in cities, are very sparingly, and only with very special precautions, admitted to these vast underground receptacles. Even the liquids of the cesspools, which up to a very recent date were allowed to be discharged into the sewers after deodorization by chloride of zinc, are now, as we shall have to report hereafter, disposed of in a different manner. It must be added, that the contents of the public urinals, and even the liquid refuse of some private houses, is still allowed access to the sewers, but not in a quantity or to an extent which appreciably affects their general contents."

The following is a description of the Paris night-soil depot :—

"The *dépotoir* of La Villette was first brought into active use in 1848. For a long time before this, the Prefect of the Seine and the Municipal Council had been desirous of removing from the north-east part of the town of Paris a nuisance which had long been a subject of complaint, being perceived, during certain winds, almost to the centre of the capital, viz., the reservoir of Montfaucon, into which, previously to 1848, the emptyings of the *fosses d'aisances* were daily voided for the purpose of being converted into manure. It was at last determined to transfer this part of the process to Bondy, at a distance of three leagues from Paris; and thus it became necessary to provide for the transport of the matter in such a way as to avoid making this transport a heavy tax upon property.

"The idea then occurred of making, on a great scale, the separation of the solid and liquid matters; of transporting the first by means of boats, and of using for this purpose the canal from Paris to Bondy. As regards the liquid matters, the idea adopted was to establish a subterraneous conduit which, from La Villette, would pass directly to the reservoirs of Bondy, *i.e.*, over a distance of three leagues (7½ miles). With a view to the separation of the solids from the liquids, the *dépotoir* was constructed. It consists of fourteen chambers, with oblong quadrilateral sides, having an inclined floor, and each of the floors crossed obliquely from one opposite angle to the other by a wide gutter communicating with all the chambers, which are connected with each other by openings crossed with lattice work, and with meshes more and more narrow from the first chamber into which the matters are thrown or emptied, onwards to the last. At the end of the last chamber is the opening of the conduit which leads to Bondy.

"These being the arrangements, and all the matters, both liquid and solid, being emptied into the first chamber, there is produced by gravitation a separation of the matters; the liquids, mingled with a certain quantity of the solid matter, flowing into the second chamber, and from it into the third, and so on successively: so that on arriving at the last compartment the matters are liquid, and scarcely give rise to any appreciable deposit. Three night-men are occupied in each chamber in removing the solids after the liquids have flowed away from them, and putting them into casks to be transported in boats on the canal to Bondy.

"The ventilation of these chambers is effected by means of a steam-engine, which is also employed in propelling the liquid matters along the conduit pipe; the level of the reservoirs at Bondy being several feet higher than that of the *dépotoir*.

"The whole of this apparently very uncleanly operation is effected in the most regular and systematic manner, and with a freedom from offence which is perfectly marvellous, considering the nature and quantity of the matters so disposed of. Nothing can exceed the cleanliness externally of every nook and corner of the *dépotoir:* even in the underground chambers which had received the matters on the previous night, the cleansing and ventilation were so perfect that very little unpleasant odour was to be discovered at 11.30 A.M.; and, according to our experience at the time of our visit, it would have been easy to pass through the whole establishment without suspecting anything so bad as the neighbourhood of even a single foul cesspool, in an establishment which nightly unloads and discharges the contents of several thousand cesspools! The same remarkable attention to cleanliness in details extended to the persons of the officials whom we found engaged; and certainly no part of the Parisian system of operations on the night-soil is entitled to more credit, as an example of perfect organization, than the *dépotoir* of La Villette."

The CHAIRMAN—Do you know whether the discharge of the night-soil into the harbour at Carnac Bunder has produced any bad effects on that part of the harbour? Has there been any silting against the wall of the Carnac Bunder on the Moody Bay side?

Mr. ORMISTON—It certainly is not visible. I was down there at low water a few days ago, and there was water for my boat alongside the wall—although I should think from what I saw in the pipe that a great deal of silt must come down. That is the case with all sewers; wherever a sewer empties it is certain to deposit material.

Colonel TREVOR—That is easily remedied by dredging?

Mr. ORMISTON—Yes.

The CHAIRMAN—Have you made any observations as to the length of time during which unpleasant results follow the discharge?

Mr. ORMISTON—As soon as it gets well away the smell is not felt on the bunder, but it is disagreeably perceptible if you are sailing through it. In certain states of the weather the wind carries the smell a considerable distance, and it is then very disagreeable.

The CHAIRMAN—Is it a mere matter of a few minutes?

Mr. ORMISTON—Generally, but sometimes for hours. If, when flowing out, the wind is light from the southward, there is a bad smell, but if the wind is from west or north it is not offensive, however much may be discharged. We have lately put a cover over the outlet, so as to discharge the material under water, and that has very materially reduced the smell: still it is a great nuisance—I have no doubt about that—and if there could be any other means of disposing of it, it should be adopted. It is possible that the

nuisance might be reduced if the soil pipe discharged into the upper end of the drain at the Carnac Bunder, but that would involve a very large expenditure of water to dilute it and break it up.

Colonel TREVOR—That would approach more closely to the ordinary condition of sewage?

Mr. ORMISTON—It would.

Colonel TREVOR—And it should be done if possible during the night?

Mr. ORMISTON—I believe the tanks, if they were increased in capacity, might be all discharged during the night.

The CHAIRMAN—If you had a reservoir on the other side of the railway clear of the overbridges, could not you pump in sea water so as to keep the sewers flushed without indenting on the supply of Vehar water?

Mr. ORMISTON—You might pump sea water anywhere.

The CHAIRMAN—Would not that do as well as fresh water?

Mr. ORMISTON—Yes; quite the same.

The CHAIRMAN—Are you able to say, Mr. Ormiston, how far the sewage matter is carried out by the tide from the Carnac Bunder?

Mr. ORMISTON—No; Mr. Aitken's experiments on the currents of the harbour will show you that.

Colonel TREVOR—These experiments do not show how long the sewage and the night-soil would remain separate from the body of sea-water, or how long the sewage would retain its smell.

Mr. ORMISTON—You can see the sewage when it is discharged from the pipe quite plainly and like a cloud on the water, but I never noticed it in that state as far down as the Custom House. You can see it for some distance, a few hundred yards generally. In a general way, you can tell better by the flocks of gulls which are gorging on it.

Colonel TREVOR—But if we had the ordinary sewers, you would not see the solid matter so far away from the mouth of the sewer?

Mr. ORMISTON—No; and if we had a plentiful supply of water, I see no objection to the actual night-soil passing into the sewers, but for that you must have a plentiful supply of water. I don't suppose that native habits and customs will be changed in our time, so far as to enable these depôts to be dispensed with. I expect that even if you do allow night-soil into the sewers, the natives would still as a rule continue their old customs and would not have water closets, and that would necessitate the continuance of the present system.

Colonel TREVOR—If I understand your proposition, it is to lay down sewers and drain them into the harbour at the nearest point by gravitation?

Mr. ORMISTON—Yes.

Colonel TREVOR—Not into Back Bay?

Mr. ORMISTON—Well, I do not much mind where they discharge.

The CHAIRMAN—You do not see much objection, Mr. Ormiston, to draining into the harbour?

Mr. ORMISTON—No; I would carry out the Paris system, except as regards the cesspools, and I think we are better off without them.

Colonel TREVOR—And as far as the portion of the town is concerned which you cannot drain by gravitation, you propose to separate the sewage water from the night-soil?

Mr. ORMISTON—I purpose to let the sewage and rainfall run off by gravitation together, and in all cases to keep out the night-soil from the sewers as much as possible: it would be collected into tanks as at present. The tanks should be enlarged and improved.

The CHAIRMAN—But about this Carnac Bunder pipe,—do you consider that the way it is laid is a satisfactory arrangement, passing as it does under the railway and under the overbridge?

Mr. ORMISTON—Seeing how things have turned out now, I think it is very unsatisfactory.

The CHAIRMAN—Supposing the stoppage had occurred in the pipe under the bridge, would there not have been immense difficulty in getting at that section of the pipe?

Mr. ORMISTON—Yes.

The CHAIRMAN—I suppose any obstruction that may occur, is quite as likely to happen there as at any other part of the pipe?

Mr. ORMISTON—I think it is much more likely to occur there, because of the bends there, and the pipe is not so well laid. I confess I did not anticipate this result.

Colonel TREVOR—Still it did not prevent the same thing occurring at Chinch Bunder. A stoppage occurred there.

Mr. AITKEN—That was a different case. The stoppage there was from the silting up into the pipe.

Mr. ORMISTON—When our reclamations are finished, which they will be next year, it will be necessary to provide more latrines—there are hundreds of people depositing their own night-soil upon the face of our temporary walls and on the reclamation. I do not object to the latter, as the earth covers it up, and they really have no place else to go to.

Mr. CRAWFORD—I think the Elphinstone Company can be compelled to construct latrines there for the workmen.

Mr. ORMISTON—The people I speak of are not our workmen. They are the bunder coolies and people from the town.

The CHAIRMAN—But you have latrines on your works already?

Mr. ORMISTON—Yes, two, which Mr. Crawford has given us. He has promised to give more.

The CHAIRMAN—Have you considered the separate scheme for the drainage of the Fort, discharging into the harbour at the Mint? Do you see any objection to the completion of the scheme for the Fort drainage?

Mr. ORMISTON—I do not. I believe it contemplates the discharge of the sewage in the ordinary way. It would require to be watched to see that plenty of water is passed down the drains. It would never do for night-soil to be left in them.

The CHAIRMAN—From your knowledge of the native community, Mr. Ormiston, do you think they could be got to adopt the watercloset system?

Mr. ORMISTON—I should think so. I do not think there is any particular difficulty about it. They use much more water in the operation than Europeans do.

The CHAIRMAN—Do you think the watercloset system would be more in accordance with the manners and habits of the natives than the dry earth system, and more easily managed?

Mr. ORMISTON—Yes; I think so. I take it that the dry earth system would be unmanageable for a city of this size.

The CHAIRMAN—Before you could introduce water closets into native houses, would you not have to rebuild nearly all the houses occupied by the poorer classes in Bombay?

Mr. ORMISTON—No. I believe the plan in Mr. Aitken's report shows pretty correctly the general section of the native town, and you will see that there the privies are in the small houses at the back of the larger ones.

The CHAIRMAN—But these are the very large houses?

Mr. ORMISTON—Latrines would require to be provided for the poorer classes.

Colonel TREVOR—Almost all the houses have these gullies between them in Bombay.

Mr. ORMISTON—Yes; and I think it is a very good thing. We propose to have them on the Elphinstone property, to allow a free circulation of air and to prevent fire from spreading.

Colonel TREVOR—Have you a latrine placed over one of your drains on the Elphinstone property?

Mr. ORMISTON—Yes.

The CHAIRMAN—How does that plan work?

Mr. ORMISTON—I do not think these latrines have been very well looked after. There has been some mistake as to who was to look after them, but with attention and a proper supply of water I do not think there will be any difficulty in working them. The great point in throwing night-soil into the sewers is to have a plentiful supply of water; without that it would be a most dangerous thing to have night-soil lying putrid in the sewers. It would be much better that the soil should be carried away as at present. I think that at present it would be very dangerous to throw night-soil into the drains in the town.

Colonel TREVOR—It is not a thing which can be done very soon.

The CHAIRMAN—Is there any other matter which occurs to you on this subject at present?

Mr. ORMISTON—Not at present.

MR. A. T. CRAWFORD *was further examined, and said :—*

The construction of the present night-soil depôt became necessary owing to the advance of the Elphinstone Reclamation Company's works at Chinch Bunder. When it was found that these works would shut off the night-soil discharge pipe for the whole of that part of the town and entirely separate it from the sea, a meeting was held between the representatives of the Municipality, of the Elphinstone Company, and of the Government, when a general plan was decided upon. That was upon the 19th June 1866, and the plan which is now in force was then decided on. It was submitted to the Bench of Justices, and it was also referred to the Consulting Engineer for Reclamations upon the 16th July. It was

reported on by the Consulting Engineer to Government, and approved by the Government on the 6th August 1866. That is all I have to say with reference to that. These are the facts as to how the matter arose when the arrangement was sanctioned, and by whom it was sanctioned.

The CHAIRMAN—Don't you think it is a great inconvenience that this tank should be on the town side of the railway and the overbridge?

Mr. CRAWFORD—I do not think there is any inconvenience from that fact; on the contrary, I think the arrangement is very convenient, because there is less cartage, and distance is saved.

The CHAIRMAN—But having regard to the stoppage which has taken place in the pipe, do you not think it would be very inconvenient if any stoppage were to occur under the overbridge or the railway?

Mr. CRAWFORD—The greatest. I cannot conceive a greater disaster.

The CHAIRMAN—Do you not think it very desirable that the depôt should be removed to the other side of the railway?

Mr. CRAWFORD—Yes, probably, if we could get the necessary ground; but at the time I have spoken of, there was no ground upon the other side, and Government never admitted our right to any land there at all. The ground is only now being reclaimed from the sea.

The CHAIRMAN—Can you tell us what steps have been taken to remedy the inconvenience which has just occurred?

Mr. CRAWFORD—Simply that it has been necessary to rip up the pipe, and probably it will be necessary to rip it up and relay from end to end a considerable portion of it. But happily the cost of it is much less than it might have been if the stoppage had been under the overbridge. If the stoppage had occurred there, the cost of the repairs would have been very great indeed.

The CHAIRMAN—Do you propose to move the tank to the other side of the bridge?

Mr. CRAWFORD—I have not had time to consider the subject. You must remember that this stoppage only occurred four or five days ago. But I may say that if we could get ground on the other side the tank might perhaps be taken there. That is, if the Municipality can afford the expense.

Colonel TREVOR—All the land there belongs to the Great Indian Peninsula Railway Company, and the Bombay, Baroda, and Central India Railway.

Mr. CRAWFORD—No, none of it; the whole of Moody Bay belongs to Government.

Colonel TREVOR—But there is a siding there?

Mr. CRAWFORD—No; there is no siding at all there.

Colonel TREVOR—Not at Boree Bunder?

Mr. CRAWFORD—Boree Bunder is a long way off. (Exhibiting a plan.) After our present experience of this obstruction, it is quite clear that something must be done by which we can easily get to the pipe, which we cannot do now. I quite concur with Mr. Ormiston that it would be a most serious matter if a stoppage took place under the embankment. At present we do not know what mischief may be done or what expense may be incurred there. Of course at the time it was made, I understood that it was properly considered.

The CHAIRMAN—Do you consider that the reservoir you have at the Carnac Bunder is sufficiently large?

Mr. CRAWFORD—No; it will have to be enlarged. That can easily be done. We have our own ground there.

Mr. ORMISTON—How, by raising it?

Mr. CRAWFORD—No; raising it would stop the works, but lengthening it would not.

The CHAIRMAN—Have you any idea of the quantity of water which is consumed there in a day?

Mr. CRAWFORD—No; I have no idea.

The CHAIRMAN—A very large quantity?

Mr. CRAWFORD—Yes; a very large quantity.

The CHAIRMAN—Has it occurred to you to use sea water instead of fresh water?

Mr. CRAWFORD—Yes; it has occurred to us to use sea water wherever we can, but there is the expense of pumping.

The CHAIRMAN—Have you any idea what the expense would be?

Mr. CRAWFORD—I cannot say what the expense would be for this particular pumping.

Mr. ORMISTON—In Paris, I believe, the roads are watered from a different set of pipes from those used by the people for drinking water.

The CHAIRMAN—They use the water from the Seine for watering the streets. If you had a pump-

ing apparatus here, the sea water would serve not only for the washing of the markets but for watering the whole of the Esplanade roads?

Mr. CRAWFORD—Yes; but you would have to go a considerable distance for the water. Anything you could construct now would be but temporary, because the whole question of Moody Bay is at present in an unsettled condition. You might go to great expense, and have to take the whole apparatus down again.

The CHAIRMAN—It would not be a very great expense, I suppose, to provide this pumping apparatus?

Mr. CRAWFORD—It would be very considerable; there would be several thousand feet of pipes to go down to the sea.

The CHAIRMAN—You would only have to go down to the head of the Carnac Bunder, which is not many hundred yards from the reservoir.

Mr. CRAWFORD—One hundred yards of piping would cost a great deal of money.

Mr. AITKEN—It would cost Rs. 7,000 to lay a six-inch pipe 100 yards—and you would require a six-inch pipe.

Mr. CRAWFORD—There is not only the expense of the piping, but the area of the Esplanade is very great, and there would be a very heavy first cost for the work from the reservoir to the end of the Carnac Bunder. It is half a mile in length; then you would have to build to a very considerable height so as to get the necessary lift or pressure for the Esplanade, if the Esplanade were combined with the work. The Esplanade has an immense area, and it so happens that at that particular point the Carnac Bunder is the lowest point on the Esplanade.

The CHAIRMAN—As to the utilization of sewage, will you give us your views on that subject?

Mr. CRAWFORD—My views are simply these: that in this country, of all countries in the world, it must succeed—as I have stated in my report. I will not say whether it will pay, but I will take it as a fact that irrigation with water does pay. No one who knows this country will dispute that fact. And the clear inference is, that irrigation will pay in India; if not, it is very curious that the Secretary of State should be advancing enormous sums of money to further it. I do not think the proposition admits of any argument at all. If irrigation pays at all, the irrigation with sewage matter must pay.

Colonel KENDALL—But irrigation will not pay on all lands. Irrigation by pumping will not pay.

Mr. CRAWFORD—I am putting the consideration of cost out of the question. I am simply saying that if water irrigation will pay, the utilization of sewage water on lands will pay.

Colonel TREVOR—It would fertilise the land most unmistakably; but would it pay?

Colonel KENDALL—What do you mean by "paying," Mr. Crawford?

Mr. CRAWFORD—Simply that lands in this country which at present lie useless, unculturable, and unproductive, for seven or eight months out of the twelve, will, by the application of this irrigation, be made productive the whole year round.

The CHAIRMAN—Then it would pay the cultivator; but would it pay the Municipality who supply the sewage? Would the cultivator give such a price for the sewage water as to remunerate the Municipality for the expense of carrying the water to the fields?

Mr. CRAWFORD—I may answer that by referring you to "C.," which is the result of the conclusions arrived at by Professor Way and Mr. Lawes in 1867 and 1868:—

"The Worshipful Commissioners, Professor J. Thomas Way and Mr. J. B. Lawes, charged with an inquiry into the best mode of utilizing sewage, &c., give the following interesting items as a summary of their most carefully conducted experiments relative to the comparative value of sewaged and unsewaged grass.

"The Commissioners sum up the result of their scientific observations, extending over eight years, as follows:—

"'(A.) The proper way to dispose of sewage liquids is by applying them continually to land, by which alone the most dangerous pollution of rivers can be avoided.

"'(B.) The financial results of such sewage applications depend mainly upon local circumstances, pumping being required on some lands, whilst on others mere gravitation effects the purpose. Heavy soils, which are often alone available, are less fit for the process than light lands.

"'(C.) All local circumstances being favourable, profits may perhaps accrue; otherwise this system merely serves to aid in defraying the expenses connected with the removal of sewage.'".

The last is the principal deduction by the Commissioners. That is exactly what I should say.

The CHAIRMAN—From your experience of the local circumstances of Bombay, what should you say as to the practical application of the third conclusion of the report to the case of the Municipality of this place?

Mr. CRAWFORD—I should say all the local circumstances are very much more favourable than they are likely to be at home, for this reason: that in England, land is always more or less saturated with moisture, and that all land there, which is culturable, is made use of more or less all the year round. In this country, cultivable land is not productive for more than four out of twelve months of the year, and I say that the application of the sewage water will make the land productive during the whole year instead of for only four or five months, and that therefore it is a fair inference profits would accrue. But I say that, whether they would accrue or not, the system would aid the Municipality very materially in enabling them to get rid of the sewage. It simply comes to this: Here is an amount of land, which, substantially, lays useless and waste for seven months in the year. Again, we have a certain amount of water which can be brought to bear upon that land, and which ought to be brought to bear upon it; and which, to a certain extent, will pay for the cost of the removal of our sewage. And I say we are bound to take advantage of it.

Colonel KENDALL—Mr. Ormiston's idea was that the cultivators would rather have fresh water.

Mr. CRAWFORD—That only exists in Mr. Ormiston's imagination.

The CHAIRMAN—Have you made experiments yourself in the matter of sewage irrigation?

Mr. CRAWFORD—I should be glad if the Commissioners would come with me, for I should be very glad to show them the results of my cultivation. I have twenty or twenty-five acres under cultivators of all classes, Parsees, Marathis, Kolis, and others; and surely if Marathis and Parsees will not object, Mahomedans will not.

The CHAIRMAN—Do these people pay for the sewage supplied to them?

Mr. CRAWFORD—At present they have been allowed to take it, and do what they like with it.

The CHAIRMAN—Do they take it themselves?

Mr. CRAWFORD—No; it is delivered to them at Worlee through box drains.

The CHAIRMAN—They have not paid for these conduits themselves?

Mr. CRAWFORD—Oh, I think there are only fifty or sixty yards of wooden trenches.

The CHAIRMAN—But they have not paid for that even?

Mr. CRAWFORD—No; but my object was to get rid of the bugbear which has been put before us, that natives objected to the use of sewage water, which is a great fallacy.

The CHAIRMAN—So far as removing it is concerned, have you had any one offering to carry it to his own premises?

Mr. CRAWFORD—No; but I wish the Commissioners would just come down and see for themselves.

The CHAIRMAN—I want to know what amount of trouble people in the neighbourhood, after seeing the results of your experiments, are willing to take to get the stuff?

Mr. CRAWFORD—Our experiments may be said to be in their infancy, but I am perfectly satisfied as to the results, and I am sure that these people would gladly take any amount of the sewage. After this year, no doubt we shall make them pay for it, for by using it they get a quantity of very unproductive land converted into a garden at once, and ground which hitherto did not yield them a pie an acre, to grow crops of radish, jowaree, and other things of that kind, which they sell to considerable advantage.

Colonel TREVOR—I think there is no doubt that these people will be ready to take it and pay a fair price for it, but the question is whether that will pay for the expense of your pumping.

Mr. CRAWFORD—You forget that if you have a system of draining you must have pumping in Bombay.

The CHAIRMAN—Would you propose that the Municipality should purchase land and conduct farming operations upon its own account, or would you limit it to selling sewage matter?

Mr. CRAWFORD—I heartily endorse Captain Tulloch's proposition, that the Municipality should buy land if it were necessary. I would even now advise that they should buy a certain amount of land and farm it out; but my impression is it will be unnecessary for the Municipality to have any land of its own, as the cultivators will be glad to get the whole of the sewage in the vicinity of Bombay. I am reminded by the Health Officer, that we shall be justified in buying land on which to cultivate fodder for our own cattle, which are very considerable in number.

The CHAIRMAN—What description of produce do your experiments extend to?

Mr. CRAWFORD—Before answering that question, I would say there is a much higher position that I would take up in reference to the utilization of sewage. In Bombay the quantity of green food for the people and for cattle is lamentably deficient. Nowhere, I suppose, is there such a small supply of green food. I speak with very considerable experience of the markets when I say, that if

double the quantity of vegetables brought into the market were to be placed in it on any morning, the whole would be brought up without the slightest difficulty. Not only so, but the demand for vegetables is so great in Bombay that the poor people are driven to consume the most worthless, unwholesome, and tasteless vegetables, such as the gourd, and the most nauseous herbs, in order to have something green to eat with their other food. And it is the same with cattle. They never get green food. Cattle in Bombay seldom get any green food in dry weather. The only thing they get to vary their ordinary grass diet is the sweepings from neighbouring stables. In consequence of the want of green food the yield of milk is always deficient and impure in quality. I therefore say that independently of the fact that a very large quantity of unproductive land would be made productive, the town would benefit indirectly to a great extent by the utilization of sewage within a reasonable distance. Feeding would be improved, prices would fall, and the condition of cattle would be improved; and I say that is an additional and very strong argument for sewage utilization in Bombay.

Colonel KENDALL—I think you mentioned that if it were necessary to raise the sewage at the sluices, it might just as well be sent on to irrigate the land as be allowed to run into the sea; but I think Captain Tulloch states at page 34 of his pamphlet, that in order to send sewage to a distance to be utilised it would be necessary to pump it about 50 feet high. Now your former answer would lead one to suppose that it would be only necessary to pump sewage 10 or 12 feet high to raise it from the foot of the main sewer to a height sufficient to enable it to run off. Now, how much of the sewage do you suppose could be utilised merely from the height to which it is lifted, so as to run off by gravitation into the sea?

Mr. CRAWFORD—The sewage is at present lifted about 17 feet.

Mr. AITKEN—18 feet.

Mr. CRAWFORD—I speak under correction of course. Mr. Aitken knows the height better than I can. I suppose the height to which it must be raised depends on the distance from Love Grove, at which it is to be utilised.

Colonel KENDALL—And how much can be utilised sufficiently near to obviate the necessity of raising it any higher?

Mr. CRAWFORD—I suppose a point between Mahim and Coorla—whether on the other side or on this side of the river I won't say. There is sufficient land there to utilise the sewage of five or six towns as large as Bombay—many thousands of acres. I think those who have stated the quantity of water required for irrigation in this country, base their calculations rather upon the amount of water required for similar purposes in England, which affords no basis for the quantity of water required in this country, where the heat is so great, with consequently greater evaporation, and the ground dryer.

Dr. HUNTER—Do you think there would be no necessity for making preparations; but that the sewage should just be allowed to sink into the ground? You must remember that your ground is now all fresh. After a time it will have become saturated with the sewage.

Mr. CRAWFORD—I don't think it would make much difference in this country.

Dr. HUNTER—Do you make any arrangement for drainage?

Mr. CRAWFORD—No; I think you are alluding to clay subsoil in England.

Dr. HUNTER—No. Is not sewage utilization in its infancy?

Mr. CRAWFORD—No; I do not think it is so in England. It has been going on for thirty years, and I think every year, every month, every day, proves more clearly the success of it.

Dr. HUNTER—At all events I think it is generally considered in its infancy. Your practical experience of it is limited, I believe?

Mr. CRAWFORD—I go simply on the broad proposition, as I have said before, that irrigation pays in India, and that sewage irrigation will pay better, or at all events as well.

Dr. HUNTER—I am restricting the inquiry to the effects of sewage utilization on the public health.

Mr. CRAWFORD—It depends entirely on where you put it. I would not advocate the use of sewage in the centre of the town.

Dr. HUNTER—Say on the Flats.

Mr. CRAWFORD—It depends whereabouts on the Flats.

Dr. HUNTER—Anywhere.

Mr. CRAWFORD—The Flats are rather large—miles in area.

Dr. HUNTER—Well, take the extreme boundary.

Mr. Crawford—I should think we might use the sewage at Sion and the different places thereabout.

Dr. Hunter—How far is Sion from the city?

Mr. Crawford—About five or six miles.

Dr. Hunter—But the result of sewage irrigation is still being debated.

Mr. Crawford—I observe that they have carried on this mode of utilising in Edinburgh for over two centuries, and I suppose it would not have been carried on during all that time if it had not paid.

Dr. Hunter—But that is how they get rid of their sewage. Its sanitary and financial aspects, I imagine, are not much considered.

Mr. Crawford—I go by much larger experiments besides this. I go by experiments which increase and multiply year by year.

Dr. Hunter—But how can crops absorb so much manure as you propose to give?

Mr. Crawford—They will, and I shall be happy to show it to you.

The Chairman—I want to reduce the word "pay" to rupees, annas, and pice, if I can. How many acres do you think you could irrigate with sewage if you divert all the night-soil of Bombay on to the land?

Mr. Crawford—At present I would not put on night-soil at all. I don't wish night-soil to be used.

The Chairman—If you use the sewage and sullage water, how many acres do you think you could irrigate according to Captain Tulloch's project?

Mr. Crawford—I should be content to take Captain Tulloch's figures at 500 acres.

The Chairman—Supposing the Municipality carried sewage in pipes to this acreage, what rent per acre per annum do you expect you would get for the water?

Mr. Crawford—I cannot possibly tell.

The Chairman—But you must have some idea if you think it will pay?

Mr. Crawford—No; it is impossible for me to say.

Colonel Kendall—What is the Collector's charge for the best Government irrigated land?

Mr. Crawford—It varies according to the distance from markets and the kind of soil.

Colonel Kendall—What rent is given for market ground in Bombay?

Mr. Crawford—Rs. 100 per acre. We have 1·06 acre of land on the Flats, which was reclaimed by burying dead cattle, for which we are paid Rs. 300 a year. But that is close to the markets and so forth. We have at Sion 4·27 acres, from which the produce has to be carried to the city by coolies, and for that we have Rs. 150 per year.

The Chairman—Per acre?

Mr. Crawford—No; for the whole. But the average rate in Bombay for garden land close to the markets is Rs. 100 a year.

The Chairman—And the tenant irrigates for himself. It is mere ground rent?

Mr. Crawford—Yes.

The Chairman—Have you any idea what the land is worth per acre to the tenant; what proportion the income bears to the amount he pays for the land?

Mr. Crawford—It is impossible for me to tell you closely. I hope I shall give you particular details in a garden I shall take you to see. The price of vegetables is ridiculously high in Bombay, and it is to be hoped that if sewage irrigation is carried out prices will be reduced.

Dr. Hunter—Have you any particular way of putting sewage on the land?

Mr. Crawford—Yes; just run on to it in native fashion.

Dr. Hunter—Just in the same way that they irrigate the gardens at Surat?

Mr. Crawford—Yes.

Dr. Hunter—And cholera is endemic in Surat?

Mr. Crawford—Why, cholera is said to be endemic in Bombay.

The Chairman—Is there any other point you wish to refer to?

Mr. Crawford—As to the kind of crops which sewage will grow, I made experiments as to what would, and what would not, succeed with sewage; and I found that every description of crop and vegetable will grow, some better than others. Every description of root grows admirably. I have tried the following, and they have all succeeded:—Lucerne, Italian ryegrass, English radishes, native radishes, tomato, beet, onions, beans, two descriptions of native vegetables, bajree, three descriptions of native legumes, pumpkins, Indian corn, vegetables, nolkhol, and jowaree. Italian ryegrass will be most successful here.

Dr. HUNTER—Does Lucerne grass turn out well?

Mr. CRAWFORD—Excellently. I attach more importance to ryegrass, because I think from the nature of it that it will live through the monsoon. It will last from year to year, as Lucerne does in the Deccan. I anticipate great profits from any green crops of that kind.

Colonel TREVOR—But you won't get a very heavy rental off ryegrass I think?

Mr. CRAWFORD—Oh yes, very heavy I think, judging from the price of grass in this country. I think jowaree for forage would pay enormously. One of the men now taking water at the back of the sluices has sown a considerable area with jowaree, which he cuts and lets grow again, and sells it for forage at a great profit. In Bombay there is a great demand for forage for cattle and horses, and sewage irrigation would to a great extent improve the supply.

(Mr. Crawford then put in an article on the sewage and manure farm at Aldershot, which appeared in the London *Times* on 23rd February 1869.)

MR. BLANEY, *Examined.*

I am quite opposed to putting night-soil into underground sewers. I do not know a single sanitary authority advocating it, and there does not seem to be a single man who has considered the subject well—I speak of Indian cities—who supports such a proposition.

The CHAIRMAN—What is your objection to putting night-soil into underground sewers?

Mr. BLANEY—In Bombay, in the first place, our gradient is almost nothing; when you come to the large sewers the disengagement of noxious gases would be very considerable. The statement which I heard that most houses in Bombay were connected with separate closets situated behind the houses has, absolutely, very little existence. The night-soil is deposited inside the houses and in the rooms in thousands of instances; direct connections of the sewers with native houses would necessitate traps and sinks; but I don't know that we could get a trap which would be beyond the reach of the tenants, and the gases would be coming into the houses with the thermometer in the month of May at from 90 to 95, which would be a very serious matter, and I should expect a heavy death-rate. I cannot find words strong enough to express what I consider would be the danger of such a proceeding.

The CHAIRMAN—You would not be in favour of introducing closets into all the native houses?

Mr. BLANEY—No, certainly not; and I do not think they could be made to answer. With respect to sink traps, they generally stand on masonry or stone work, and the perforated holes are supposed to be a kind of strainer. Now we know that in most of the cities in Europe where they exist, servants generally take them up to let the slops go down more quickly, and in this way the gases are allowed to escape into the house.

The CHAIRMAN then explained to Mr. Blaney the plan which had been put in by Captain Tulloch, by which, owing to a break in the pipe, no gases could get into the houses.

Mr. BLANEY—There would be serious objections even to this plan, as indeed to all the drainage schemes I have seen. Captain Tulloch, too, as far as I know, proposes to have shaft ventilators for the houses; he does not give the size, but I suppose they would be 3 in. or 4 in. in diameter.

Captain TULLOCH—I don't know to what you are referring. I don't remember it. I don't think I recommended anything of the sort.

Mr. BLANEY—I will read from page 29 of Captain Tulloch's report on the drainage of Bombay. (Mr. Blaney then read the extract.)

Captain TULLOCH—I see now to what you refer. That would be outside the house, not inside.

Mr. BLANEY—"Wherever water is used in a house," is the first sentence in the paragraph, "I should insist on a proper sink, with perforated holes in it, and with a syphon trap being put down. A ventilating pipe connected with the house drain would be carried up above the roof of the dwelling."

The CHAIRMAN—The ventilating pipe would be put outside.

Mr. BLANEY—Then there would be no sewers connected with the waste water or night-soil in the house? If there were such a system, I should not altogether approve of it even if there was no night-soil in the drains, for I have serious objections to sewage water alone without night-soil.

(Captain TULLOCH here explained his plan to Mr. Blaney by means of diagrams.)

Mr. BLANEY—Some houses have no free outside except the road. That is a capital arrangement where there is a sink entirely unconnected with the houses. With regard to Captain Tulloch's system of sewer ventilation, there would be a strong current of air passing out of these ventilating

house pipes. But we have also sewer ventilators. In considering these two in relation to one another —there would be 23,000 of these ventilating pipes—there seems no objection to the sewer ventilators if the night-soil did not go into the sewers. The gases issuing from the pipes of low houses would vitiate the atmosphere of adjacent high ones; this could not be tolerated. If I lived in a high house, I should object to Bappoo having his pipe placed over against my bed-room window. It is perhaps an engineering question, but it is a sanitary one also, whether the ventilating pipes would not put out of function the ventilating shafts in the street sewers. The theory is that there would be an upward current in both. We pass the gases of the street sewers through charcoal filters, by which they are to be deodorised. We want an upward current in the ventilating pipes and also in the street sewers, and I don't know that we should get anything of the kind. I don't put this forward as anything fatal to Captain Tulloch's scheme, but it is a point which I came upon just now in the course of an examination into the question which I think it only right to mention, as, if I am right in my supposition, it is a sanitary matter of some consequence, for if the ventilating house pipes would act freely, the charcoal filters in the sewer ventilators would not be of any use.

The Chairman—What system of conservancy do you consider best adapted to the exigencies of a town like Bombay?

Mr. Blaney—I look upon the question—and it is one to which I have given long and anxious attention—as by no means settled. We hear of many good men coming forward with conservancy schemes; we meet all sorts of men, and get all sorts of opinions; but as yet I think we have heard of no scheme adapted to the city, and I think our best plan is to wait for a time before we adopt a costly drainage system, as after a plan had been executed at a great cost we might change our views, or find that the scheme we had carried out did not answer. It has been found in places where it has been adopted that great mischief has resulted from the underground sewer system, and that the death-rate has been increased and diseases engendered which were unknown before—and this, I fear, would be the case here.

The Chairman—We don't want to bind you down to any absolute expression of opinion as to any scheme.

Mr. Blaney—The night-soil must be kept out of the sewers. There is some that goes in—as Mr. Aitken said—and it passes into the drains by the new Fort system. Mr. Aitken and I have been down into these sewers together. There is the water closet arrangement in the Elphinstone Circle; it is small, but as complete as possible, and I do not hesitate to say that an extension of that system would be very detrimental to the health of the people of Bombay. I believe that the halalcore system, although it is an expensive and an imperfect system, is capable of much improvement. It is one of those services which the Municipality must organize and the people must pay for. It is a system that we must not depart from until we are sure that we have found a better one. With regard to the sullage and waste water from houses—if it could possibly be done—I am quite at one with Mr. Ormiston that we should improve our own present drains, and not have flat-bottomed ones with broken sides and bad gradients, and should construct new ones wherever they are deficient.

The Chairman—Would there be any objection to let the drains discharge by gravitation into the harbour or on the foreshore as they do now?

Mr. Blaney—I have always been very strongly opposed to harbour pollution; but with better halalcore arrangements—not putting the night-soil into the harbour, for we find all sanitary authorities strongly opposed to that—the ordinary sewage water might be discharged into the sea temporarily.

Colonel Trevor—What would you do with the excreta?

Mr. Blaney—The proper plan appears to be to employ it in agriculture. It seems running away from the difficulty by putting it into the sewers and letting it run into the harbour. Some time ago we conducted some float experiments in Bombay to see which way the sewage would go when pumped into the harbour. We know its specific gravity is greater than water. I don't mean fœcal evacuations, but everything that may collect in the sewers, and it will settle down and cause a silting in the harbour, just as it does at Carnac Bunder and Moody Bay at present.

The Chairman—How would you get rid of your night-soil for agricultural purposes?

Mr. Blaney—That seems an entirely hygienic matter; I don't see my way clear to do it at once for the whole city. I say, in connection with that question, that we have not at all considered what we might have done for ourselves in the way of experiment with the dry earth system. I won't alarm anybody here by proposing that system. I will not at present say it is the best; but we should have had some experiments as to what were, and what were not, its sanitary advantages. In any place where a great number

of people were congregated together, the Municipality might have tried the plan upon a small scale, and so demonstrated beyond all doubt the impracticability or otherwise of the plan; but we have done nothing of the kind; we have gone on the mere assumption that it would cost lakhs and lakhs of rupees per annum. I think that is not the way to deal with the question; I think it was the duty of the Municipality to deal with it by making experiments, which would have been of immense value in settling that part of the conservancy question.

The CHAIRMAN—Do you think you could carry out the dry earth system in the monsoon?

Mr. BLANEY—Not over the whole city.

Colonel TREVOR—Then what is the good of trying a series of experiments on a scheme which you can't apply to the town?

Mr. BLANEY—You would not be spending much money; you must remove the night-soil in some way.

The CHAIRMAN—But you would have to bring in and remove the dry earth as well as remove the excreta, and that would involve a greater cost than is incurred at present.

Dr. HUNTER—Has the dry earth system been found to succeed altogether as much as its advocates would lead one to infer?

Mr. BLANEY—It has been very largely resorted to in India, but its success depends upon certain local conditions; it will not do if you have to bring the earth from a long distance on coolies' heads, but here we have trains constantly coming in, and the cost of the trains such as come to the Back Bay works are not very great.

Colonel TREVOR—That soil costs a great deal.

Mr. BLANEY—It costs less than it could be brought in for in any other way.

Mr. ORMISTON—They could bring it cheaper by boats.

The CHAIRMAN—Do you think the utilisation of sewage would be advisable in a sanitary point of view, that is, utilising it within the island of Bombay itself?

Mr. BLANEY—Not within the inhabited portion of it.

The CHAIRMAN—Sion, Worlee, and those places?

Mr. BLANEY—I would prefer if it was further away beyond Coorla where our mountains of Municipal rubbish are taken to.

Dr. HUNTER—The sewage of Bombay is much lighter than sea water.

Mr. BLANEY—We have not had it so according to Captain Tulloch.

Dr. HUNTER—The sewage would float on the water in the harbour.

The CHAIRMAN—You say what goes in under the name of sewage is heavier; but do you think the fœcal matter is heavier?

Mr. BLANEY—I mean, if you take the contents of a sweeper's basket or of a night-soil sewer, you will find these heavier than water.

Dr. HUNTER—But road scrapings don't go into the sewers, except in the monsoon.

Mr. BLANEY—Then there is all that people put in through their water closets.

Colonel TREVOR—How would that go out of the town by your system of halalcores? I think you recommended that we should retain the halalcore system. Now I don't understand how all the sewage of Bombay is to go out under that system.

Mr. BLANEY—Not liquid sewage.

Colonel TREVOR—Is there no harm in that?

Mr. BLANEY—Of course there is.

Colonel TREVOR—Then you retain the whole of that in Bombay?

Mr. BLANEY—I spoke about improving the drains. That is an engineering question, and I think it must necessarily end in pumping.

Colonel TREVOR—What is the proportion of liquid and solid?

Mr. BLANEY—The proportion of excreta to urine? One in sixteen.

Colonel TREVOR—In the dry earth system where would the urine go to?

Mr. BLANEY—Into the dry earth, or there should be a separate arrangement made as has been done in some of our largest gaols.

The CHAIRMAN—It is one thing to deal with a gaol and another with a free community; there you have discipline, and the people are overlooked and made to do what they are ordered. That is not what we have to consider. We are not here to make experiments, but to recommend the system of drainage best adapted to the whole community of Bombay, not individual units.

Dr. HUNTER—What is the relative density of the sewage of Bombay and the sea water?

Mr. BLANEY—Perhaps I should best explain that in this way. If I go to the end of the Carnac Bunder and see the pipe discharging during flood tide, I find the sewage turning round into Moody Bay, where it takes its position upon the foreshore.

Dr. HUNTER—Floating?

Mr. BLANEY—It does not float; as soon as it goes into the water it mixes with it and becomes deposited.

Colonel TREVOR—Is it not consumed by the gulls or fish?

Mr. BLANEY—Some of it.

Colonel TREVOR—Is not that a good way of disposing of it?

Mr. BLANEY—Very little is disposed of in that way.

The CHAIRMAN—Have you seen any deposit in Moody Bay?

Mr. BLANEY—Yes; and any Custom-house officer would be happy to give you his experience of it.

Colonel TREVOR—Are the reclamations just as foul?

Mr. BLANEY—From the people?

Colonel TREVOR—Is the foreshore of the reclamation just as bad?

Mr. BLANEY—No; I think Carnac Bunder stands A 1 as a foult spot. I know the quality of the fevers there; they are extremely dangerous; I have had thirty years' experience of them.

The CHAIRMAN—Do you think the health of the town improved or not by reclamation?

Mr. BLANEY—Improved.

The CHAIRMAN—Then don't you think a wall better than a foreshore?

Mr. BLANEY—If you have deep water up to the wall; but the sewage then will not go away, for we shall not have a sea wall with deep water all the way from the Light-house to Sewree.

The CHAIRMAN—But you will have it from Colaba to Mazagon within a very few years.

Mr. BLANEY—Even then I think there are great objections to putting night-soil into the harbour.

Colonel TREVOR—But none to putting it into the ground?

Mr. BLANEY—That depends upon whether the process be good. By throwing it into the harbour we don't improve the harbour, we only throw it away. Agricultural operations can be improved year by year.

Colonel TREVOR—As far as sanitary science is concerned, would it not answer every purpose if it left the island by the harbour?

Mr. BLANEY—It would foul the water.

Colonel TREVOR—What would be its proportion to the water in the harbour?

Mr. BLANEY—We have 100,000 tons of garbage per annum; and if that is thrown into the harbour, it is not merely a question of sanitation, but of silting up the harbour. I do not consider it a proper mode of disposing of rubbish which contains an immense quantity of organic matter.

Colonel TREVOR—No one is disposed to throw garbage into the harbour.

Mr. BLANEY—If the liquid sewage is free of the excreta and free of the other rubbish, it would not do so much harm.

Colonel TREVOR—It is not a matter of opinion, but a matter of fact, that the water in the harbour changes every three or four days.

Mr. BLANEY—If all the excreta went out to sea, then I should not hesitate to throw the rubbish into it also. If the tide is capable of carrying away the one, it could also carry away the other. We need not expect any annihilation ~~of excreta in sea~~ water.

The CHAIRMAN—Taking the comparison of the two schemes, which do you consider preferable in a sanitary point of view: the discharge of sewage into the harbour, or irrigating the land with the sewage?

Mr. BLANEY—The discharge of sewage into the harbour with the night-soil compared with irrigation?

The CHAIRMAN—Yes. Speaking in a sanitary point of view?

Mr. BLANEY—If the sewage was taken out of the city it would perhaps be no more detrimental to health than the sewage thrown into the harbour.

The CHAIRMAN—Then you think they are both on a par.

Mr. BLANEY—Yes.

The CHAIRMAN—And the question is one of expense?

Mr. BLANEY—Yes; but this question of expense is a very serious one for the city.

Colonel TREVOR—Expense is inseparable from any scheme.

Mr. BLANEY—Yes.

Dr. HUNTER—The Commission wish to see which is the best plan of disposing of the sewage with reference to the health of the people. We do not expect to cure the evil, we only hope to remedy it.

Mr. BLANEY—Yes, we could perhaps improve the halalcore system, and we might make it more useful perhaps if people did not go about the streets with the baskets; the Municipality might have air-tight carts going through the different streets.

The CHAIRMAN—You would have to open the carts at every house, and so you would let the gas out.

Mr. BLANEY—In the other case there is a large basket exposed.

The CHAIRMAN—Do you think the halalcores do their work pretty thoroughly?

Mr. BLANEY—Yes; since Dr. Hewlett's organisation I think they have been well looked after.

The CHAIRMAN—You are speaking from your own experience?

Mr. BLANEY—Yes; I think it is proved so.

Colonel TREVOR—I thought from calculations which have been made here that they do not take out an eighth of the whole quantity of excreta and urine daily produced?

Mr. BLANEY—What was the estimated quantity to be taken out by the Municipal halalcores? At Malabar Hill and other places the Municipal halalcores don't go, so it can only be a rough estimate.

Colonel TREVOR—I think it was stated at one-eighth.

The CHAIRMAN—The daily average is about 100 carts, each cart containing 16 cwt.; so that the daily average of night-soil taken away is 80 tons.

The COMMISSIONER—There are other baskets besides that; about 2,500 baskets go directly into the tip, and that is about 100 more carts.

Mr. BLANEY—Taking 2½ oz. of fœcal matter and 40 oz. of urine per individual, there would be about 60 tons of excreta per day.

The Commission then adjourned.

ELEVENTH DAY, MONDAY, MAY 3.

The following Commissioners were present :—

ANDREW R. SCOBLE, Esquire, *Chairman.*
Colonel KENDALL, R.E. | Lieut.-Col. TREVOR, R.E. | Dr. HUNTER.
Dr. LYON, *Secretary.*

The Commission resumed at 2 o'clock on Monday, in the Durbar Room, Town Hall.

CAPTAIN TULLOCH, R.E.

Captain TULLOCH, at the meeting before last, had been requested by Colonel Kendall to show clearly the area of the town which drained into the main drain, and the portion of Bombay which drained on to the Flats according to his scheme. He now gave a full explanation, pointing out the different places on the plan ; and then proceeded :—

Sometime after I prepared my project I was reading some old papers, written some by Mr. Ormiston, some by Colonel DeLisle, and some by Colonel Trevor, and I was very much pleased to find that Colonel DeLisle recommended strongly that the existing sewers should be made use of to the utmost. Now that is just what I propose to do.

The CHAIRMAN—But I thought you were to have a line independent of the present main drain through the native town ?

Captain TULLOCH—I am speaking now merely with reference to the removal of rain water.

Colonel KENDALL—But Colonel DeLisle never contemplated that all the water collected in the town was to be pumped up. He always contemplated that the greater part of it would be discharged by gravitation.

Captain TULLOCH—Yes, if it could be done, but the saving would be so trifling—only one lakh of rupees capitalised. I have devoted days and days to this subject, and tried to see if it would be cheaper to discharge a portion of the rain on the harbour side of Bombay, but I cannot make it out that it would be cheaper, because you would have to build such a long line of sewers.

Colonel KENDALL—How does it run off now ?

Captain TULLOCH—The way I propose to take it—by gravitation.

Colonel KENDALL—It goes by gravitation to the other side—that part where you said the ground slopes towards the harbour ?

Captain TULLOCH—Yes; I was speaking with reference to the portion of the town which slopes in the other direction. It has never been proposed by me to take in the rain water into my sewers (Showed on the plan the portion of the town which drained into his main drain.)

The CHAIRMAN—In the seven years from 1860 to 1866, there were only seventeen days out of six hundred and ninety on which the rainfall was over three inches in the day. Having regard to that circumstance, do you retain your opinion that we should provide for a rainfall of fourteen inches in our scheme for the drainage of the town?

Captain TULLOCH—I think it would be best, for then the houses would never become damp. The danger when there is a heavy fall of rain is that the water collects and saps the foundations of the houses.

The CHAIRMAN—But the water would all be run off in 36 hours.

Captain TULLOCH—By that time it will have soaked the foundations. I assure you that when Mr. Crawford and I went through the town on the 9th August, the whole of the way along—in fact, almost one square *mile*—was literally under water.

The CHAIRMAN—How many houses in that district fell?

Captain TULLOCH—I have no idea.

The CHAIRMAN—Do you know if any pucka built houses fell at all?

Captain TULLOCH—I do not know.

Mr. RUSSEL AITKEN—I do not think any fell. I was called upon to look at several which were said to be coming down, but they are still standing.

Captain TULLOCH—It is very little extra expense, and it makes the thing complete. If you think only 8 inches should be provi ded for, this sewer could be reduced in size, and a reduction of 3 lakhs made in the expenditure.

The CHAIRMAN—From Bellasis Road to Love Grove?

Captain TULLOCH—That is all. Whether you take one, two, or three engines, it does not matter for purposes of comparison between the system of taking the rain in the direction of Love Grove and in the direction of Mody Bay. Half goes one way and half the other.

Colonel TREVOR—Except that on the harbour side it discharges into the sea, and the rain discharged on to the Flats requires to be pumped up.

Captain TULLOCH—The rain must always be pumped up. It would never be there a single hour.

Mr, AITKEN—I have taken all the calculations, and I think it is quite impossible that the engines can pump it up.

The CHAIRMAN—With your engines could you rely upon being able to pump up fourteen inches as fast as it came?

Captain TULLOCH—They will beat twelve inches of rainfall collected over two square miles, but not fourteen inches.

Colonel TREVOR—Is not there a great deal of gratuitous expenditure all throughout in your engines?

Captain TULLOCH—The sewage requires three engines of 150 horse power each. Even if you could let the rain off by gravitation, you still require three engines of 150 horse power each for the sewage.

Colonel TREVOR—But if we don't want sewage irrigation and discharge straight into the sea, you won't require anything like that power?

Captain TULLOCH—That, of course, I have never considered, because the idea of pumping sewage into the sea there would never be tolerated. I have never thought of that, but I can give it you.

Mr. AITKEN—Captain Tulloch provides 450 horse power to pump the whole of his sewage and rainfall into the sea at Love Grove, to take 14 inches from about half the area, and only three feet more lift than at Colaba, where I provide 650 horse power.

Captain TULLOCH—At what level does your main drain enter the sea?

Mr. AITKEN—Three feet below sea level.

Captain TULLOCH—My main drain is 37, and there is a difference of eight feet at once. And these engines, which you suppose will simply work 150 horse power, will work up to 450 horse power when required in an emergency. It is like the engines in a steamer. They are called 200 horse power engines, but at a pinch they will work up to 800 horse power.

Mr. AITKEN—But you must deduct the friction of the engine and the pumps.

Captain TULLOCH—I have deducted everything. You should see the duty done by the Crossness engines. If you like to take in a less rainfall into the main drain, then the size of the sewer may of course be reduced, but you will still want the same number of engines, because the engines are calculated not for the rainfall at all, but for sewage.

Colonel TREVOR—If I mistake not, Mr. Rawlinson, in one of his reports, says we should not provide for these extraordinary rainfalls in our sewers.

Captain TULLOCH—That is for your consideration.

Colonel TREVOR—It is a matter for the purses of the people here, I think.

The CHAIRMAN—Your scheme depends on the pumping, which is the main element in it. Have you ever considered the contingency of a European war, and the stoppage of the supplies of coal from England in connection with your scheme?

Captain TULLOCH—No, I have not. I think under any circumstances we could always get coal

from the P. & O. Company. They have a large supply here, and they have a very large fleet, and I think at a pinch they could supply us.

The CHAIRMAN—I apprehend in the event of a war nobody could tell whether the P. & O. Company would be able to supply us. But the question is whether, from the resources of the country, you could get coal in the event of a European war.

Colonel TREVOR—When the Nerbudda valley is opened no doubt you will be able to get coal from there.

Captain TULLOCH—There are a number of coal fields open to us; there are the Australian ones.

The CHAIRMAN—That is, if you keep the sea. Is there a reasonable prospect of getting country coal so as to render us independent of sea-borne coals in the event of a war?

Captain TULLOCH—If you could not get country coal, which we might obtain from the Nerbudda valley, we might use wood, and the supply of coal would be likely to be stopped for only a very short time.

Colonel TREVOR—You would find that very expensive.

The CHAIRMAN—I want to know whether, from the study which you have given to the subject, you think there would be supplies in the country itself of fuel for the pumping engine?

Captain TULLOCH—I never looked at the question in that aspect; the opinion of others, of Colonel Trevor or the Commissioner, would be more valuable than mine on that point; but if the Nerbudda valley is to be opened to Bombay I cannot see that any difficulty would arise, and moreover there will be coal from Calcutta, though it may cost a little more.

Colonel TREVOR—I am afraid the Municipal revenue would soon be exhausted if we had to get coal from Calcutta, for it would be very expensive. I think if the drainage was principally diverted into the harbour, and the drainage of only one square mile went down to Love Grove, and at the same time that provision for the storm water was reduced to three inches instead of 14 inches, we might do with engines of 45 instead of 450 horse power.

Captain TULLOCH—The size of the engines is not dependent upon the rainfall at all, but on the sewage. In all water works and drainage works they have a spare engine. I have three of 150 horse power, but if you only provide for a rainfall of three inches, one engine would get over all the difficulty, because in a small rainfall like that one-third of it would soak into the soil; it is in the heavy rainfalls when you get so very much more. The only difference providing for a less rainfall will make will be that, instead of having three engines of 150 horse power, I shall have two 150 horse power condensing engines, and two of 100 horse power high pressure engines. The four engines will be actually cheaper than three condensing engines.

Colonel TREVOR—Your calculations all depend upon the utilization of sewage.

Captain TULLOCH—No; I am presuming that the drain will take two or three days to discharge, as it now goes off to the Flats. A little extra outlay to make the scheme perfect is not worth consideration; but if you think it better to take only three inches of rainfall you can estimate the cost at once at 5 lakhs.

Colonel TREVOR—It all depends on the utilisation of sewage; it is an immense lift you give to your sewage.

Captain TULLOCH—In that case you might have only two engines—that would be quite enough for the next 15 years.

Captain TULLOCH—Let me say a word upon the point of the stoppage of the drain which has been brought up as an argument against my project. If you will refer to page 28 of this report—I did not know at the time what I had written exactly—but if you will permit me I will read the latter portion of the paragraph: "But for the earthenware pipes I propose to make arrangements by which every manhole may, as occasion demands, be converted into a flushing reservoir. Suppose there is an obstruction in a pipe, then the mouths of the pipes at the bottom of the manhole above the obstruction will be closed, and the manhole filled with as much water from the nearest Vehar main as may be considered necessary. The mouth then of the pipe to be flushed will be suddenly opened by a lever from the surface of the street, and the water will rush with great velocity to remove the obstruction. I feel confident that very few obstructions will ever occur which cannot be removed by these means. Should it, however, become necessary at any time from the fracture of a pipe or other incident to dig down to the work, the proposed short distance between every two man-holes will enable the workpeople to ascertain with great precision the exact position where the damage has occurred. Consequently no labour will be thrown away or useless expense incurred in digging up more

of the street than necessary." If this pipe which is now stopped had been laid down in the way I proposed, such a thing could never have happened.

Mr. AITKEN—I think that is not the question; the other pipe was made to be flushed with Vehar water to clear out the obstacles.

Captain TULLOCH—Did you ever know a pipe 2,600 feet long laid down without a manhole?

Mr. AITKEN—It was not intended that it should be.

Captain TULLOCH—Is it an earthenware pipe?

Mr. AITKEN—No; it is a cast iron pipe. It was never intended that the sweepers should empty all their cutchera and rubbish into it.

The CHAIRMAN—Is there any other point, Captain Tulloch, upon which you wish to give further explanation?

Captain TULLOCH—No.

The examination of witnesses then concluded, and the Commission rose.

APPENDIX B.

To J. B. LYON, ESQ., Secretary to the Bombay Drainage and Water Supply Commission.

SIR,—With reference to your letter No. 11 of 1869, dated the 23rd instant, and the brief conversation I had with the Chairman of the Committee on the 25th instant, I beg to state my views for the Committee's information on the question of the proposed increase of the Water Supply for Bombay.

2. I have read Mr. Aitken's report on the extension of the Bombay Water Works, and have thought a good deal on this question. That the Vehar water has been one of the great means of sanitary improvement in Bombay requires to me no demonstration. Indeed I have always looked upon the Vehar water to be at least as great a sanitary reformer by itself as all the branches of the Health Department put together. I regret, however, that I am unable to concur in the propriety of immediately taking up any one of the projects now before the Commission with the view of augmenting our water supply.

3. Taking the figures as given by Mr. Aitken, we have, it seems, a supply of 12 gallons daily per head, sufficient for the wants of the present population of Bombay. The ordinary *handa* or chatty used by our people, contains about 3½ gallons, and Mr. Aitken's calculation, therefore, gives nearly three and a half *handas* or chattyfuls, which is quite sufficient for the average daily consumption of the people.

4. I have read of the average quantities supplied to the inhabitants of several large towns in Great Britain and Europe. But, in the matter of cleanliness and water supply, I feel bound to say that we are not in want of any such models. Besides, I think that if the present supply be economised, first by using salt water to water our roads; 2ndly, by preventing waste at Municipal posts and water stands; 3rdly, by adopting a better system of checking the private service pipes; 4thly, by the construction of *pakka* cisterns like the *bunds* at Poona; and lastly, by the prevention of waste at the lake itself, either by repairs to the existing works, or still better by the construction of a solid *pakka* bund or bunds at a proper distance from the present dam or dams, the people will get a larger number of gallons from the existing source than they obtain at present.

5. The present Municipal wells on the island are not at all what they should be. They are too few in number for the wants of the native public, and their construction is quite *kacha* when compared with the Poona *bunds* and other similar works, which seem to defy, as it were, the progress of time and the combined deteriorating influences of the tropical regions.

6. Besides the adoption of these measures, another main may be laid down from the present lake itself. An opening has been already left, and during the height of the monsoon water is allowed to escape by this second channel into the valley below. The cost of this will be between 12 to 15 lacs,

and if care be taken to select proper material, we should get a new pipe flowing throughout the year, or at those seasons when it may be required by the community.

7. Some parts of the native town are at present in greater want than others. And greater care must be taken in selecting sites for new cisterns and watering posts in those parts which are not now properly supplied.

8. From the report in the papers, I see one of the witnesses would close all the private wells in the town. I regret that some fine wells were closed on the Esplanade. And although I fully appreciate the benefits derived from the use of Vehar water, I should strongly deprecate interference with private property, unless it were absolutely required for the public good. There is plenty of good water in different parts of the island, and a number of good wells also.

9. An extension of the water supply will be desirable when the population of Bombay become very much greater than it is now, and when our finances are—I will not say flourishing—but at least in solvent condition. At present the people do not know where we financially are. And looking to the number of questions which have been brought before the infant Municipality of Bombay within the last three years, I feel bound to say that we are working under a high pressure system, and compressing the Municipal works which ought to extend over three decades into as many years. It is very considerable to undertake additional works whether at the Canbere Caves, or at Tulsi Pavai or Shewla. I am not a medical man, but looking to what has been said and done in Bengal and other places, I think it will be a serious calamity to Bombay, if it should be resolved to remove the night soil by means of water carriage through the drains. I hope this mistake may be avoided, and all the necessity for the present heavy expenditure will cease.—I have the honour to be, Sir, your most obedient servant,

VISHWANATH N. MANDLIK.

Bombay, 29th March, 1869.

APPENDIX C.

To J. B. LYON, Esq., Secretary to the Bombay Drainage and Water Supply Commission.

SIR,—I have the honour to acknowledge the receipt of your letter dated the 3rd instant, received on the 4th, and in reply I have great pleasure in submitting my views on the subject of Water Supply, which will come before the Commission.

There can be no doubt whatever that a more plentiful supply of pure water, both for domestic use and for purposes of irrigation, is most urgently required. The benefits derived by the community from the Vehar Water Supply cannot be over-estimated. I believe that the opinions of medical men are unanimous that the public health of the city has very greatly improved in consequence. Seeing, therefore, that an ample supply of pure water is of such vast importance to this populous city, I consider that a second reservoir is an urgent necessity, and that its construction should not on any account be delayed, because, apart from the urgent necessity of an additional supply, there is the contingency that the Vehar water might, owing to some accident, be shut off altogether from the island for a considerable time, leaving us without a water supply at all, and considering the great increase that has taken place in the population of Bombay, such a disaster would be attended with very serious consequences. I earnestly trust therefore that the result of the labours of your Commission will be a strong recommendation that the construction of another reservoir should at once be proceeded with. As to where this new reservoir should be, and how it should be constructed, I do not, of course, pretend to give an opinion. I am satisfied that the subject will be carefully considered by our best professional authorities, and that the plan will be adopted that offers the greatest advantages in the way of water supply, combined with moderate and reasonable outlay in the cost of construction.

There, therefore, remains the question of cost, which is no doubt a most important one. The money must be raised by loan, and if the finances of the Municipality were well managed and put on a proper footing, the credit of the Corporation ought to stand high in the money market, and enable us to raise by loan what is required. To meet the charge for interest on the loan, and a small sinking fund of say two per cent. per annum, I would suggest a house rate of 2 or 3 per cent. to be levied on the occupiers paying a rent of no less than Rs. 42 per annum, thereby exempting the poorer class altogether

from this tax, and giving them at the same time an abundant supply of water gratis. Although largely interested in landed property in the island, I do not wish you to suppose that I take a selfish view of this question, because, although I suggest that the rate should be on occupiers, it would, of course, affect the owners indirectly, as rents are no doubt to some extent affected by the question of taxes.—I have the honour to be, Sir, your most obedient servant,

BYRAMJEE JEEJEEBHOY.

Breach Candy, 8th April.

APPENDIX D.

TABLE SHOWING THE COMPOSITION OF BOMBAY SEWAGE WATER.

		From commencement of new covered drain.	From the united Fort drains.
Organic matter in solution	Grains per Gallon.	5·25	16·80
Do. Suspended	,,	13·93	64·19
Lime	,,	10·91	21·24
Magnesia	,,	3·05	3·87
Potash	,,	6·96	6·94
Chloride of sodium	,,	19·86	28·26
Sulphuric acid	,,	1·68	·58
Phosphoric acid	,,	6·62	9·96
Carbonic acid	,,	7·42	12·69
Oxides of iron and zinc	,,	1·18	5·73
Silica, alumina, &c.	,,	13·34	31·06
Ammonia	,,	6·23	10·59
	Total.....	96·43	211·91

I. B. LYON, *Secretary to the Commission.*

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